FLOOD PLAIN MANAGEMENT STUDY

ON

OAK CREEK AND WILLOW CREEK

AND

ADJACENT CRITICAL FLOOD PLAIN AREAS IN

BOTTINEAU AND McHENRY COUNTIES, NORTH DAKOTA

Prepared By

United States Department of Agriculture
Soil Conservation Service
Bismarck, North Dakota

For the

BOTTINEAU, McHENRY, AND ROLETTE COUNTY WATER RESOURCE DISTRICTS

OAK CREEK AND WILLOW CREEK WATER RESOURCE DISTRICTS

In cooperation with the

NORTH McHENRY COUNTY, ROLETTE COUNTY, AND TURTLE MOUNTAIN

SOIL CONSERVATION DISTRICTS

AND THE

NORTH DAKOTA STATE WATER COMMISSION

AUGUST 1985

F O R E W A R D

This report defines the flood characteristics along and adjacent to Oak and Willow Creeks in Bottineau and McHenry Counties, North Dakota. Land uses along the streams are transportation, residential, commercial, industrial, agricultural, recreational and wildlife. Despite moderate agricultural damage by floods in previous years, there is increasing pressure for development of the flood plain.

This cooperative report was prepared for the guidance of local officials in planning land use and regulating development within the flood plain. The 10-, 50-, 100- and 500-year frequency flood events were selected to represent degrees of major flooding that could occur in the future. The 100-year 1/ and the 500-year 2/ floods are frequencies considered for planning land use and development in the flood plain. Potential flooded areas are defined by flood hazard photomaps that show the approximate areas subject to inundation. Flood profiles show the water surface elevations for the selected events. Typical valley cross sections are presented to indicate ground levels across the width of the valley with the overlying flood depths. The flood profiles and flooded area photomaps are based on conditions at the time of the study (1985).

This report does not imply any federal authority to zone or regulate use of the flood plain; authority to zone and regulate rests with state or local governments. Technical data is provided for the potential future adoptic local land use controls to regulate flood plain development. Since this report identifies flood problems, it will give guidance for the development,

1/ A flood which has a 1 percent chance of being equaled or exceeded in any year (also called "base" flood).

2/ A flood which has a 0.2 percent chance of being equaled or exceeded in any year.

with environmental considerations, of flood damage reduction techniques such as flood control structures, channel improvement, removal of obstructions and flood proofing for use in an overall Flood Plain Management Program.

The assistance and cooperation of the Bottineau, McHenry, and Rolette County Water Resource Districts; Oak Creek and Willow Creek Water Resource Districts; North McHenry County, Rolette County, and Turtle Mountain Soil Conservation Districts; North Dakota State Water Commission; and private citizens in carrying out this study is appreciated.

OAK - WILLOW FLOOD PLAIN MANAGEMENT STUDY

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INTRODUCTION

The purpose of this cooperative study is to identify flood hazard areas along Oak and Willow Creeks in Bottineau and McHenry Counties, North Dakota, and provide technical data necessary to implement an effective local flood plain management program. Increasing pressure to develop flood plain areas is becoming apparent as competition for land grows. Increasing land values and scarcity of undeveloped areas in which to expand often result in flood plain encroachment. Nonregulated development and encroachment frequently reduce flood conveyance, thereby increasing flood stages and overall flood losses.

Since the advent of federal laws governing financing within flood plains, many financial institutions are reluctant to lend. Federal agencies cannot finance projects in these communities, unless there is assurance that the area is flood free or can be protected.

It is imperative that flood plains in agricultural areas be defined so that the planning and location of valuable properties can be controlled and areas identified where future flood control measures can be applied.

This flood plain management study was requested by the Bottineau, McHenry and Rolette County Water Resource Districts, Oak Creek and Willow Creek Water Resource Districts, North McHenry County, Rolette County and Turtle Mountain Soil Conservation Districts, through the North Dakota State Water Commission, under the 1978 Joint Coordination Agreement with the Soil Conservation Service. Priorities regarding such studies are set by the North Dakota State Water Commission. The study was carried out in accordance with the December 1981 Plan of Study between the Bottineau, McHenry and Rolette County Water Resource Districts; Oak Creek and Willow Creek Water Resource Districts; North McHenry County, Rolette County and Turtle Mountain Soil Conservation Districts; the North Dakota State Water Commission; and the Soil Conservation Service.

This Flood Plain Management Study consists of Willow Creek and Oak Creek. A total of 67.85 channel miles were studied.

The Willow Creek Study begins at its confluence with the Souris River in Section 24, T. 159 N., R. 77 W. and proceeds upstream to the east section line of Section 12, T. 159 N., R. 75 W. (Channel Mile 39.24).

The Willow City Flood Hazard Analysis was completed in August of 1975. An additional 10 years of stream gage data and complete downstream water surface profiles were available for the current study. The new and additional information allowed an update of the hydraulic and hydrologic analyses for Willow City. The 100-year water surface was lowered 0.3 feet on the west edge of Willow City and raised 0.7 feet at the east corporate limit.

The Oak Creek Study begins at its confluence with Willow Creek in Section 31, T. 160 N., R. 75 W. (Channel Mile 23.49 of Willow Creek) and proceeds 25.45 channel miles upstream along Oak Creek to the south Extra Territorial Limit of Bottineau, North Dakota, in Section 31, T. 162 N., R. 75 W. The study resumes at the north Extra Territorial Limit of Bottineau, in Section 19, T. 162 N., R. 75 W. (Channel Mile 30.25), and continues to the north section line of Section 17, T. 162 N., R. 75 W. A Flood Insurance Study for the city of Bottineau was published in March 1979.

The "Extra Territorial Jurisdiction Law", passed by the 1975 North Dakota Legislature, provides communities with zoning authority outside the corporate limits. The 1981 North Dakota Legislature amended and re-enacted the law to include each quarter-quarter section within one-half mile of the corporate limits for incorporated cities with a population of 5,000 or less. The Extra Territorial Jurisdiction for the city of Willow City is covered by this study.

Flood plain management studies carried out by the Soil Conservation Service result from recommendations found in A Report by the Task Force on

Federal Flood Control Policy, House Document No. 464 (89th Congress, second session), Recommendation 9(c), "Regulation of Land Use."

SCS assists state agencies and communities in the development, revision, and implementation of their flood plain management program by carrying out cooperative flood plain management studies (FPMS's) in accordance with Federal Level Recommendation 3 of "A Unified National Program for Flood Plain Management," and Section 6 of Public Law 83-566. The principles contained in Executive Order 11988, Flood Plain Management, directs that "all executive agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved."

Potential users of flood plains should base planning decisions upon the advantages and disadvantages of each location. Potential flood hazards are often unknown and consequently the managers, potential users, and occupants cannot always accurately assess these risks. In order for a local flood plain management program to be effective in the planning, development and use of flood plains, technical expertise is needed to collect, evaluate and interpret flood hazard data. To help establish local flood plain management programs, SCS will:

1. Assist the state and local units of government by preparing appropriate technical information and interpretations for use in their flood plain management programs.

2. Provide technical services to managers of flood plain property for present and future land uses.

3. Improve basic technical knowledge about flood hazards in cooperation with other agencies and organizations.

This report contains aerial photomaps, water surface profiles and typical valley and channel cross sections indicating the extent of flooding which can

be expected within the study areas. The 10-, 50-, 100- and 500-year frequency flood discharges and elevations are included. The hydraulic analysis for this study were based on unobstructed flow. The flow elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

The North Dakota State Water Commission or the Soil Conservation Service will, upon request, provide technical assistance to federal, state and local agencies and organizations in the interpretation and use of the information contained in this study.

DESCRIPTION OF STUDY AREA

The Flood Plain Management Study Area is located in the state of North Dakota Hydrologic Unit 09010004.

The temperature range within the study area is large from summer to winter, and on occasion from day to day. In the winter, outbreaks of arctic air brings bitter cold. Most winters have many days with temperatures below zero. The mean temperature for the winter months of December, January and February is 5.5°F. Summers are warm and pleasant with an average temperature of 65.0 °F for the months of June, July and August. Average annual precipitation varies from 15.5 inches at Willow City to 17.8 inches at Bottineau. June is usually the wettest month of the year, with an average annual precipitation of 3.3 inches at Bottineau and 2.9 inches at Willow City.

Oak and Willow Creeks have their sources in the glaciated highlands of Bottineau and Rolette Counties known as the Turtle Mountains. Oak Creek flows south from the highlands through Bottineau, North Dakota and onto a nearly level lake plain of former glacial Lake Souris. The channel meanders southwest across a narrow flood plain that is mantled with alluvial sediments.

About 3 miles north of Gardena, Oak Creek loses its identity on the lake plain and flows south and southeast in a manmade channel for about 7 miles. During spring runoff, blockage by snow drifts cause floodwaters to flow overland along this reach. Oak Creek again flows in its natural channel for about 3 miles before joining the common flood plain of the westward flowing Willow Creek. Willow Creek flows southeast from the Turtle Mountains toward Dunseith. Here it turns south and southwest, meandering across glacial ground moraine. About nine miles northeast of Willow City, it begins to flow across the former glacial lake plain. About 6 miles northeast of Willow City it turns and flows west to join the westward flowing Ox Creek at Willow City. Oak Creek joins Willow Creek 6 miles west of Willow City. Here Willow Creek turns southwestward as it enters McHenry County. It meanders southwest and south for about 5 miles where Snake Creek enters the drainage pattern from the southeast. At this point, Willow Creek turns westward and flows its meandering path to its junction with the northwestward flowing Souris River.

NATURAL VALUES

"Flood plains, including their land and water ecosystems, have evolved from natural forces over tens of thousands of years. Yet, after two centuries of our Nation's history, the natural values of most of our flood plains have been significantly altered by human actions and in many cases degraded or destroyed. Thus, there is a national concern to carefully manage the remaining natural values of flood plains." 1/

1/ See Reference 13

The Oak Creek and Willow Creek Flood Plain Management Study consists of the flood plains and similar adjacent resource areas. The natural values discussion will occur by dividing the study area into four reaches (as shown on the vicinity map, page v).

Reach one begins in McHenry County, at the Souris River, within the J. Clark Salyer National Wildlife Refuge (also known as the Lower Souris National Wildlife Refuge) and ends upstream in Bottineau County at the confluence of Oak and Willow Creeks. Reach two begins at the confluence of the two creeks continuing upstream on Willow Creek and ending near the north side of Willow City. Reach three begins at the confluence of the two creeks continuing upstream on Oak Creek and ends just south of Bottineau. Reach four begins on Oak Creek just above Bottineau continuing upstream to the end of the study at the Turtle Mountains Escarpment.

Reach one contains nealy half of the prime farmland soils in the study area. Approximately 35 percent of this reach is considered prime farmland and an additional 5 percent is considered prime farmland where drained. There are relatively undisturbed areas including a 40 acre U.S. Fish and Wildlife Service Waterfowl Production Area Easement and private riparian areas with diverse plant and animal communities. Activites that degrade natural values include overgrazing, drainage, vegetative clearing and cropland production. Activities that benefit natural values include tree plantings and grass seedings.

Reach two consists of approximately 30 percent prime farmland and less than 5 percent prime farmland where drained. Relatively undisturbed areas include two 160 acre U.S. Fish and Wildlife Service Waterfowl Production Area Easements. Beneficial activities to natural values include tree plantings, grass seedings and maintenance of some relatively undisturbed private areas.

Degrading activities include channel modification near Willow City, overgrazing, drainage and cropland production.

Reach three has nearly 20 percent prime farmland and 20 percent prime farmland where drained. Activities which degrade natural values include several miles of channel modification, cropland production, drainage and overgrazing. Beneficial values in this reach include relatively undisturbed areas, tree plantings and grass seedings.

Reach four has insignificant amounts of prime farmland and prime farmland where drained. Activities which degrade natural values include overgrazing and residence structures. Beneficial activities include private, relatively undisturbed areas.

The overall study area has the potential to provide increased natural values. Some of these values include natural moderation of floods; improved water quality; ground water recharge; large and diverse populations of plants and animals; and cultural, scientific, recreational, and aesthetic sites in addition to productive agricultural sites. These values should direct that development and modification of flood plain resources be viewed with caution and careful assessment of potential adverse impacts on the beneficial, natural values.

The 1978 Stream Evaluation Map - State of North Dakota classified reach 1 and 2 as value Class II, a high priority fishery resource. The study area outlets into the Souris River, which is considered a value Class I, the highest valued fishery resource.

This study area is not, nor is it proposed to be, listed in the National Wild and Scenic Rivers System. No critical habitat for threatened or endangered species was identified in the study area.

A cursory review of cultural resource information indicates five site leads have been identified near the study area. Three sites occur in

Bottineau County as follows: 1) Section 19, T162N, R75W, Kind: Sinclair Monument, Ref.: REAP 1978, Rec. by: Tweton, Date: 1978; 2) Section 19, T162N, R75W, Kind: Bottineau (original site), State Station, Ref.: REAP 1978, Rec. by: Tweton, Date: 1978; 3) Section 19, T162N, R75W, Kind: Dana's Grove Post Office, Ref.: REAP 1978, Rec. by: Tweton, Date: 1978 and two sites occur in McHenry County as follows: 1) Section 11, T159N, R76W, Kind: Wires Post Office, Ref.: REAP 1978, Rec. by: Tweton, Date: 1978 and 2) Section 24, T159N, R76W, Kind: military campsite - Twining Expedition - 1869, Informant: Robert C. Fields, Address: J. Clark Salyer Refuge, Source: field work, Rec. by: C.L. Dill, Date: Dec. 1975.

The lack of sites in this area reflects the lack of archeological field investigations rather than a lack of past human settlement.

Source: "Preliminary Field Reconnaissance and Literature Search of Cultural Resources in the Burlington Dam Project".

FLOOD HISTORY

Most of the flooding occurs in the spring of the year, usually in April. Large floods occur from spring snowmelt runoff due to winter accumulation of snow and frozen soil conditions. Figure 2 through 5 show photographs of recent floods. Large floods in recent years occurred in 1943, 1951, 1952, 1954, 1969, 1975, 1979.

FLOOD POTENTIAL

Potential flood areas within the study area include primarily agricultural land. Flood damages include eroded land, sediment deposition, crop and pasture damage, washed-out fences, and weakened roads and bridges.

Restrictive bridges, dense vegetation, obstructions, and sharp meanders in the channel all contribute to the severity of flooding within the flood plain.

Floodwaters in the study area rise rapidly. Duration of flooding normally ranges from 7 to 14 days for significant flood events.

A 500-year frequency flood within the study area will inundate approximately 5,300 acres adjacent to Oak Creek and 11,200 acres adjacent to Willow Creek. A 100-year frequency flood will inundate approximately 4,100 acres adjacent to Oak Creek and 9,600 acres adjacent to Willow Creek. Flooding occurs in and around the cities of Bottineau and Willow City.

Figures 6 through 26 show potential flood stages at various locations of the study area.

FLOOD PLAIN MANAGEMENT

With flood hazard information, the counties can minimize future flood losses by planning for the protection of existing structures within the flood plain area. The overall plans for industrial, commercial and residential areas, streets, utilities, parks and schools must recognize the need to develop outside the flood plain.

A coordinated planning procedure such as this is a vital part of any comprehensive flood plain management program. Effective flood plain

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A coordinated planning procedure such as this is a vital part of any comprehensive flood plain management program. Effective flood plain management involves public policy and action for the wise use and development of the flood plain. It also includes such measures as collection and dissemination of flood control information, acquisition of flood plain lands, construction of control structures and enactment of ordinances and statutes regarding flood plain land use and development.

A viable local flood plain management program is comprised of numerous elements, some of which are: structural flood control works to protect

existing development; regulations to guide new development; flood insurance to protect existing and new buildings; and individual protection measures such as flood proofing.

Flood Control Measures

Various structural flood control measures to reduce the flooded area include enlarged bridge openings, dikes, floodwater retarding dams, floodways and channel work, or a combination of the above.

Flood Plain Regulations

Flood plain regulations are designed to permit realistic use of flood plain areas without increasing potential damage. Among the various elements used to accomplish this are zoning ordinances, subdivision regulations, building codes, and sanitary and utility regulations. For a guide, see "A Perspective on Flood Plain Regulations for Flood Plain Management", Corps of Engineers' Manual EP 1165-2-3-4.

Flood Insurance

Under the National Flood Insurance Act of 1968 (PL 90-448), the Federal

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Flood Insurance

Under the National Flood Insurance Act of 1968 (PL 90-448), the Federal Emergency Management Agency (FEMA), Federal Insurance Administration (FIA), is authorized to carry out a National Flood Insurance Program (NFIP). This program which makes flood insurance coverage available to all walled and roofed structures and their contents used for residential, business, religious and agricultural purposes, buildings occupied by nonprofit organizations and those owned by state or local governments or their agencies. The unincorporated areas of Bottineau County within the study area currently do not participate in the National Flood Insurance Program. Willow Creek Township in McHenry

County and the cities of Bottineau and Willow City currently participate in the Flood Insurance Program.

In these areas, owners and occupiers of all buildings and mobile homes are eligible to obtain flood insurance coverage. It is recommended that persons within or adjacent to the delineated flood hazard areas maintain flood insurance on both the structure and contents.

Further inquiries about the flood insurance program should be directed to the Office of the State Engineer, North Dakota State Water Commission; the official state coordinating agency for flood insurance.

Other Measures

Land use and other regulatory controls including zoning, subdivision regulation and building codes play an important role in flood plain management. In order for these measures to be effective, it is important that the communities take action to implement other programs and measures to supplement these controls. A few possible measures to protect and control developments in flood prone areas are: (1) open space land acquisition programs, (2) urban renewal programs, (3) preferential tax assessment, (4) flood proofing of existing structures, and (5) public policy governing the construction of utilities and public facilities such as bridges and streets.

The Office of the State Engineer, upon request, will provide assistance in flood proofing techniques, the implementation of a flood warning system and establishment of a local flood data collection program.

Recommendations

Some specific recommendations for alleviating the flood situation along the flood plains of Oak and Willow Creeks are:

1. Adoption of local land use and zoning regulations for all flood plain areas. The basic purpose of flood plain regulations is to control development on the flood plain consistent with nature's needs for conveyance of flood flows.

2. Flood proofing existing or future buildings that otherwise cannot be adequately protected. (See U.S. Army Corps of Engineers "Manual of Flood Proofing Regulations", EP 1165 2 314 and "Elevated Residential Structures Reducing Flood Damage Through Building Design: A Guide Manual", published by the Federal Insurance and Hazard Division, HUD).

3. Using as much of the flood hazard areas as possible for parks and other open space uses.

4. Installation of a dike system to protect intensively developed flood plain areas (especially residential, farmsteads and other buildings).

5. Increase the areas of bridge and culvert openings to minimize the restriction of large floods.

6. Improve hydraulic characteristics of channels through enlargements, oxbow cutoffs and active maintenance programs consistent with environmental guidelines. Channel improvement was considered from the confluence of Oak Creek to channel mile 11.55. Based on 10-year frequency flood protection and estimated construction costs of $1,347,900, this channel improvement is economically feasible (benefit/cost is 0.57:1).

With more detailed survey and geologic data, a lower frequ channel could be feasible.

7. Construct upstream floodwater retarding dams, as feasible, to retard flood flows. None appear to be economically feasible under SCS criteria.

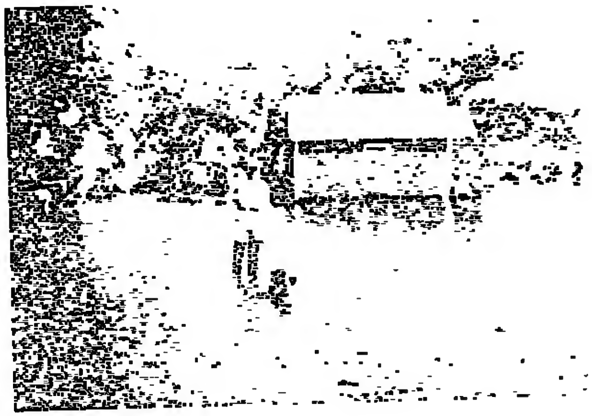
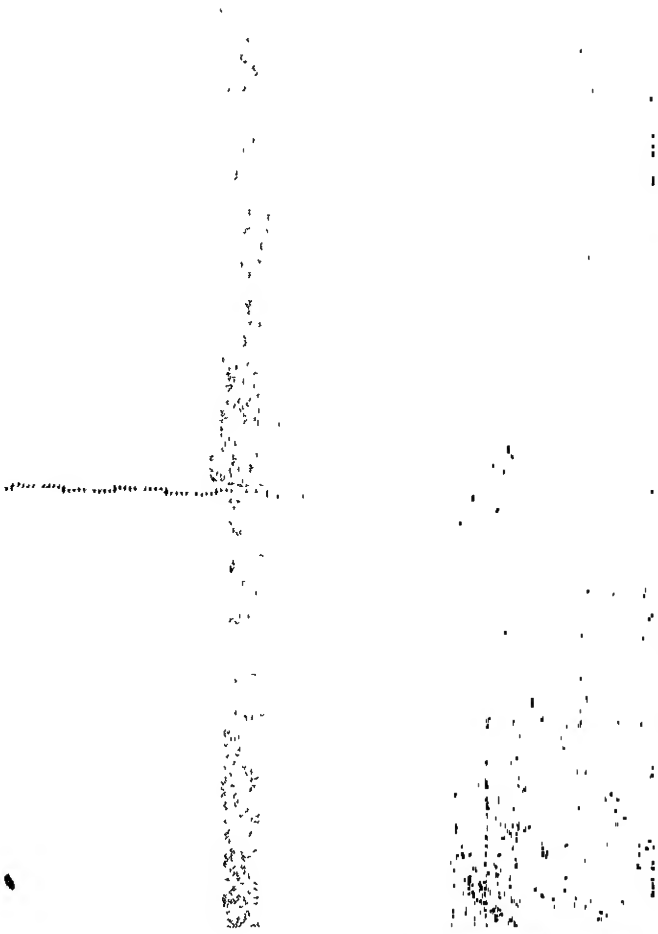


Figure 2 - 1954 Flood at Mile 9.4 of Willow Creek   Photo by Werner Kitzing

Figure 3 - 1969 Flood at Mile 9.4 of Willow Creek
Photo by Werner Kitzing

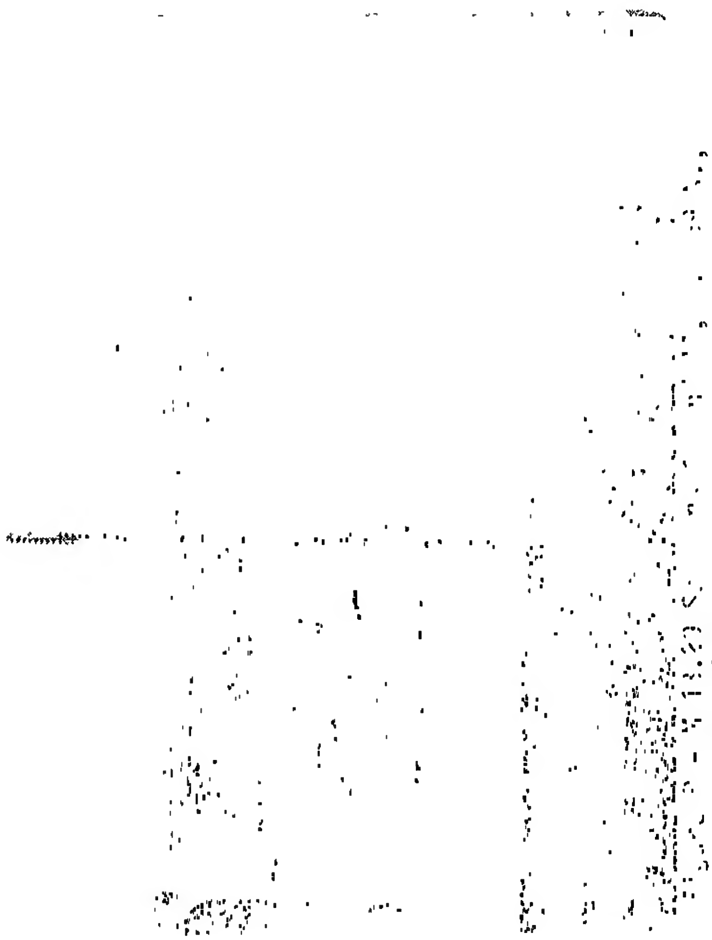
Figure 4 - 1969 Flood at Mile 1.02 of Oak Creek   Photo by Lyle Bickel

Figure 5 - 1975 Flood at Mile 6.58 of Oak Creek   Photo by Ken Rosenau



R. 76 W.

Figure C - M 5.99 in Sec. 23, T. 19 N., R. 76 W.



R. 76 W.

R. 76 W.

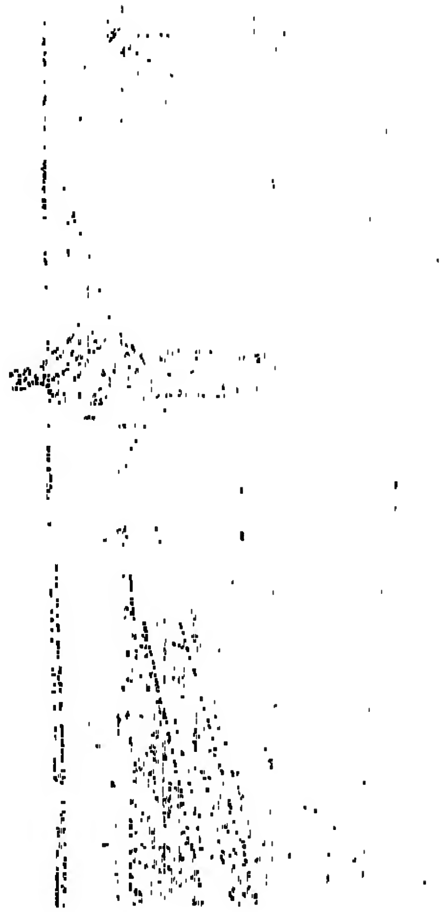


Figure 11 - M 21.76 Sections 1, T. 159 N., R. 76 W. and 36, T. 160 N., R. 76 W.

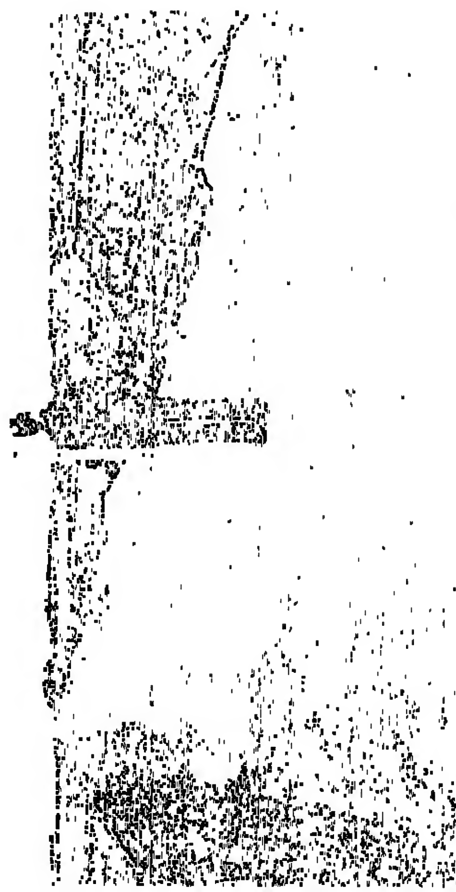


Figure 10 - M 18.28 Sections 1, 2, 11 and 12, T. 159 N., R. 76 W.

POTENTIAL FLOOD STAGES - OAK CREEK

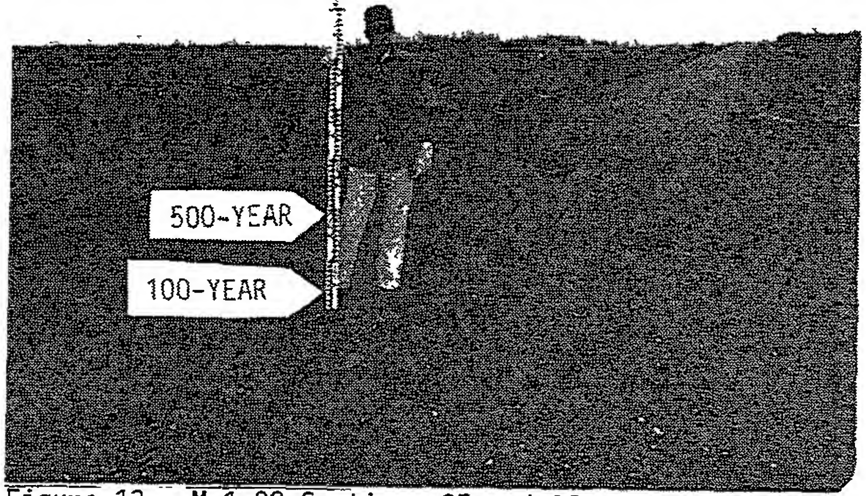


Figure 13 - M 1.02 Sections 25 and 36, T. 160 N., R. 76 W.

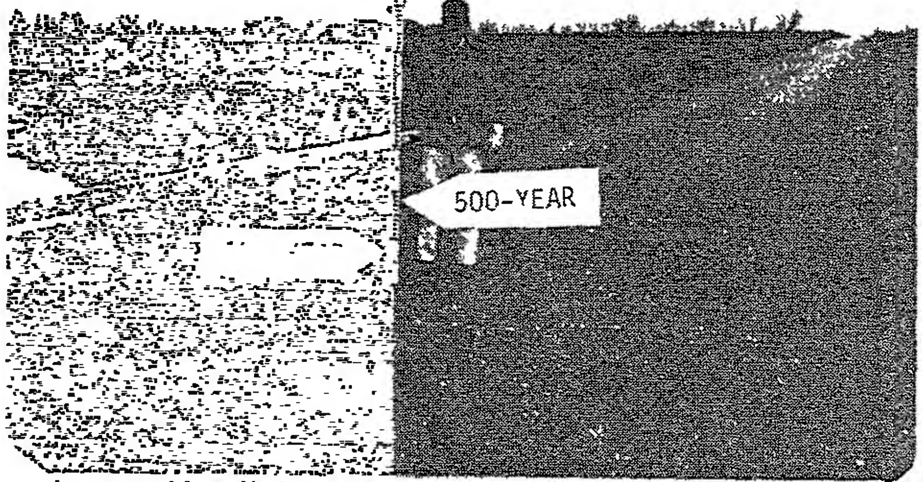
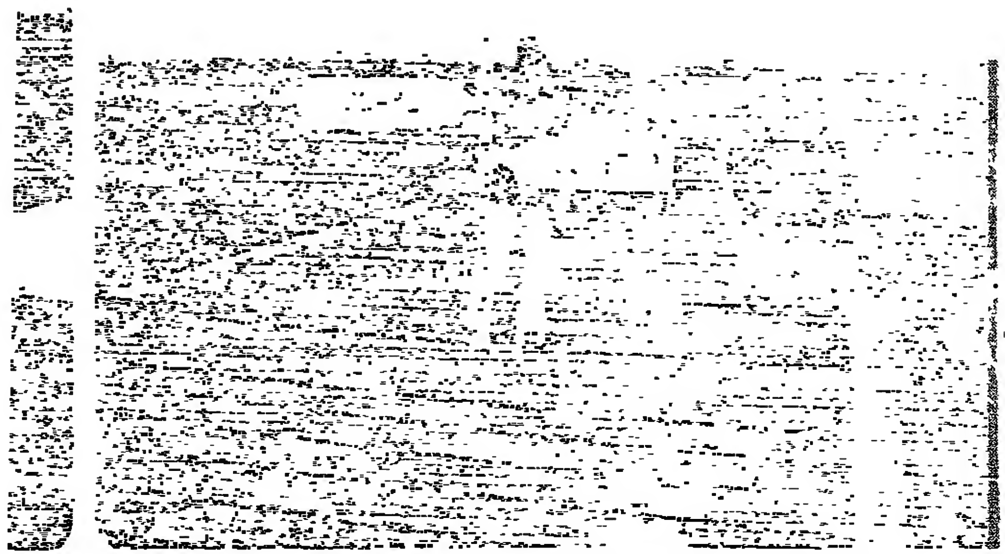


Figure 14 - M [illegible] Sections 19 and 30, T. 160 N., R. 75 W.



W.

Figure 16 - M 4.88 Sections 13 and 24, T. 160 N., R. 76 W.

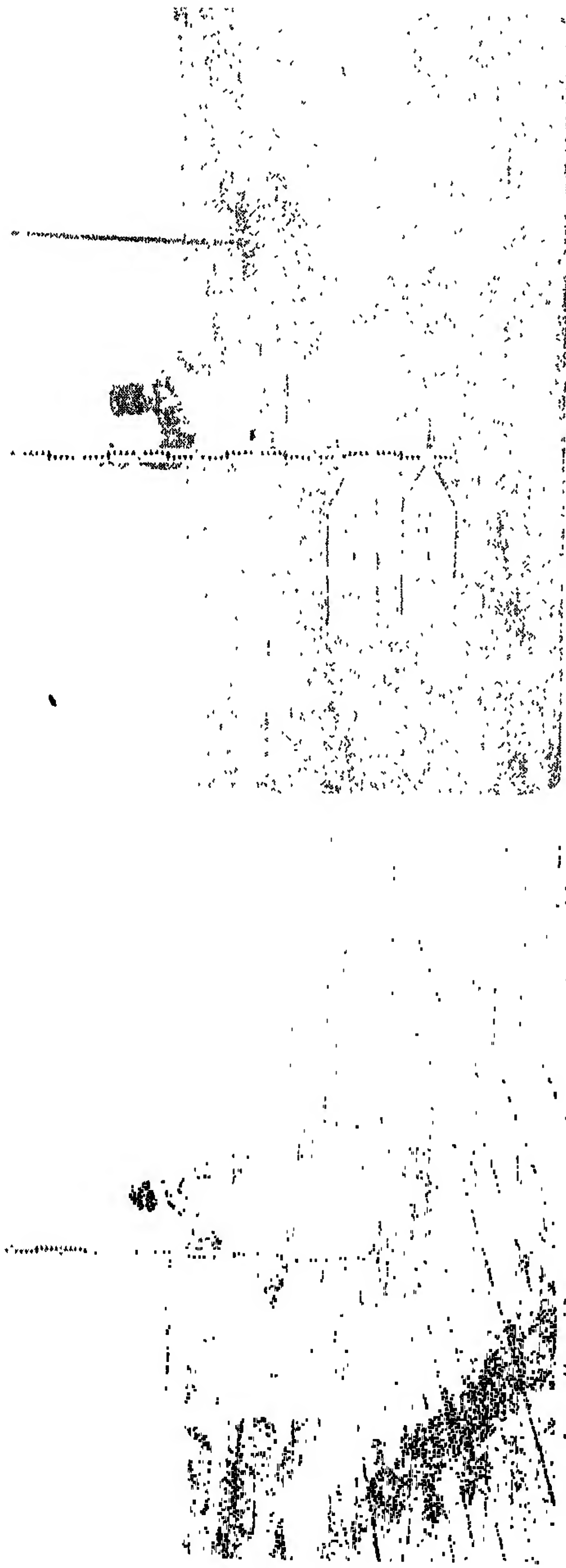
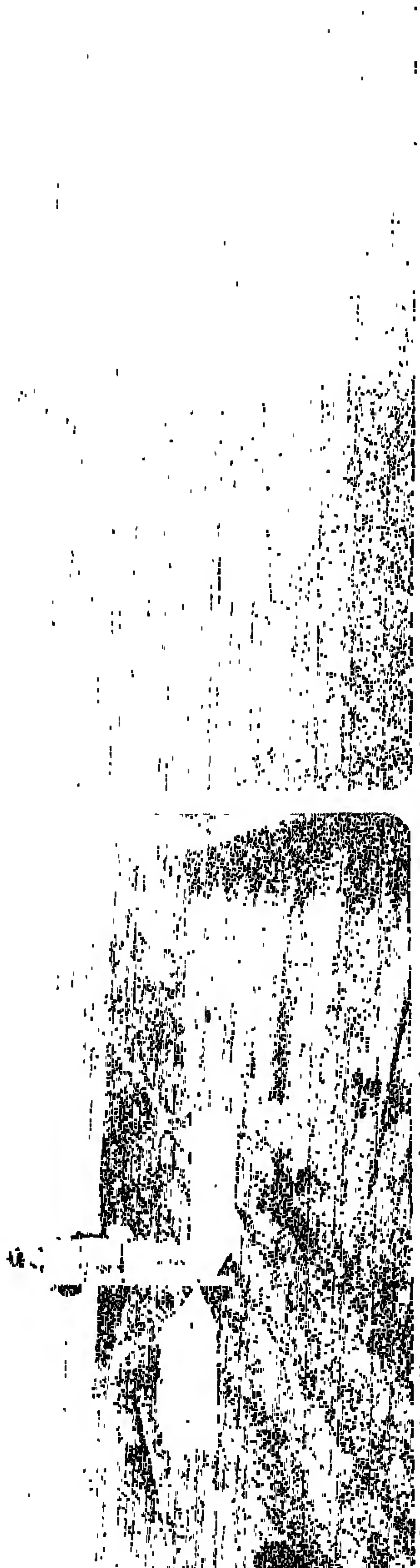


Figure 18 - M 6.58 Sections 11 and 14, T. 160 N., R. 76 W.

T. 160 N., R. 76 W.



R. 76 W.

R. 49 W.

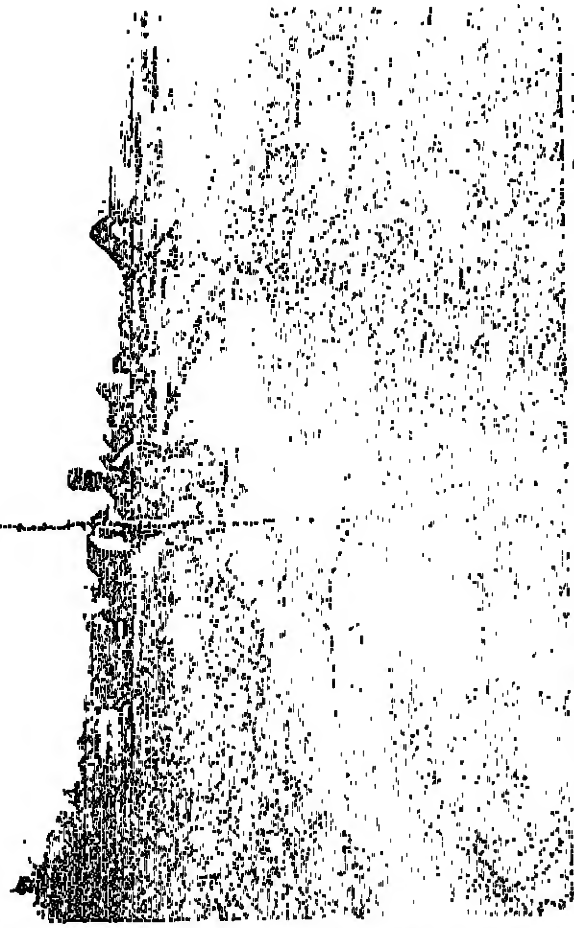


Figure 22 - M 20.53 in Section 7, T. [illegible]

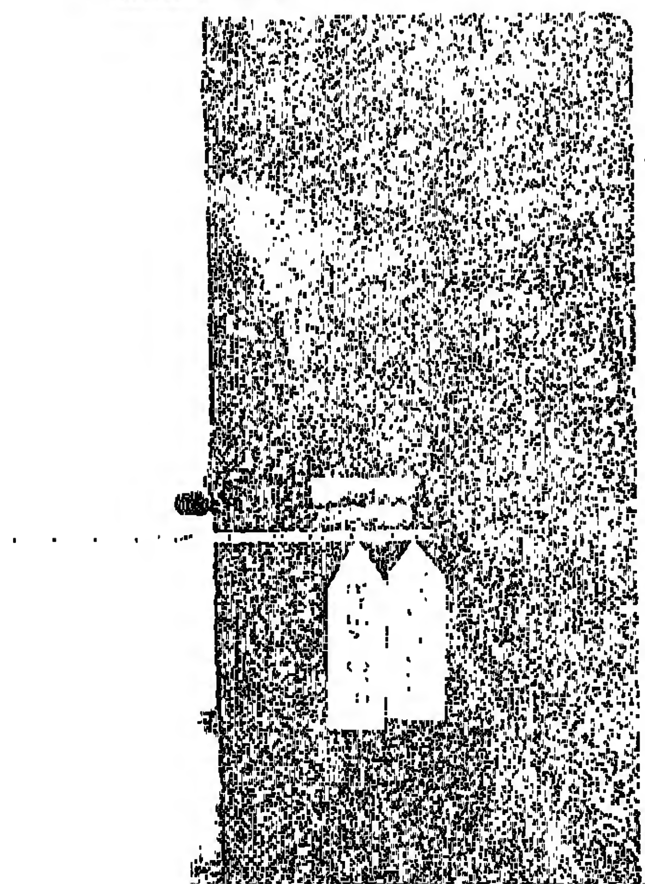
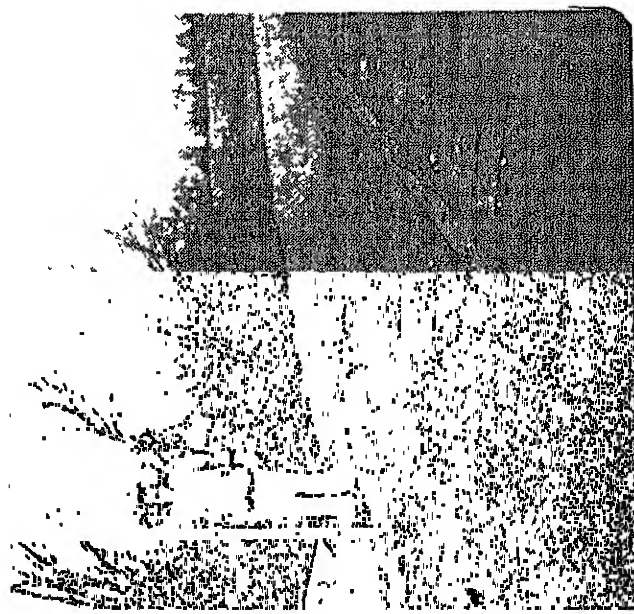


Figure 21 - M 19.82 Sections 7 and 18, T. 15 [illegible]



[illegible] in Section 6, T. 32 N., R. 49 W.

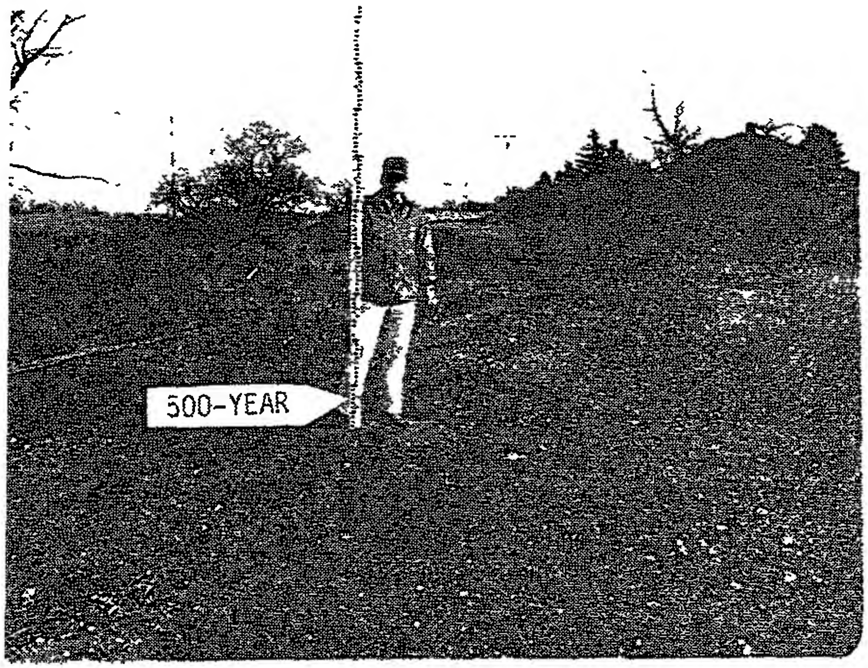


Figure 24 - M 24.81 Sections 1, T. 161 N., R. 76 W. and 36, T. 162 N.. R. 76 W.

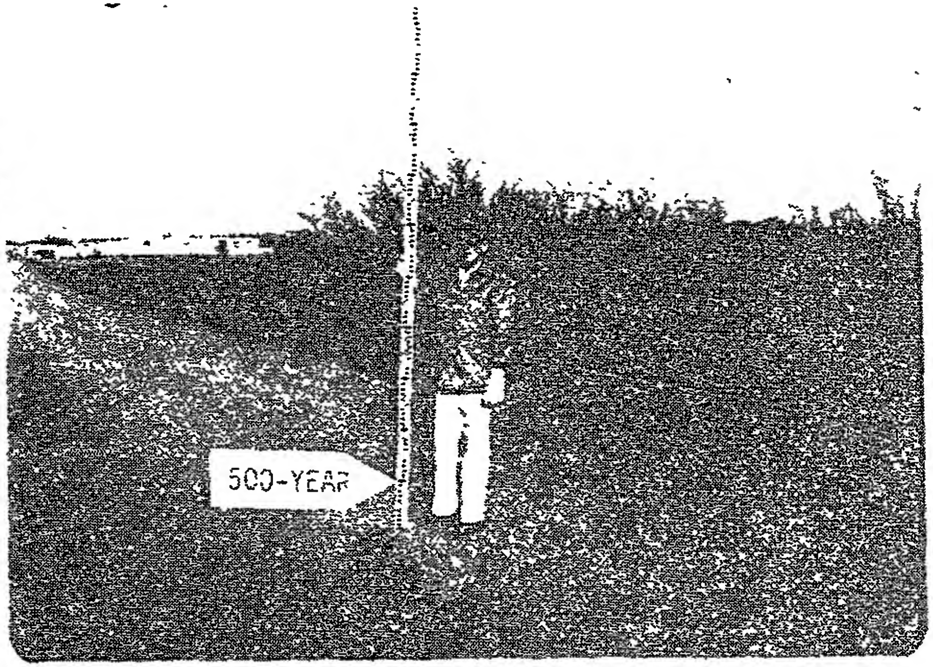


Figure 25 - M 25.05 Sections 31, T. 162 N., R. 75 W. and 36, T. 162 N., R. 76 W.

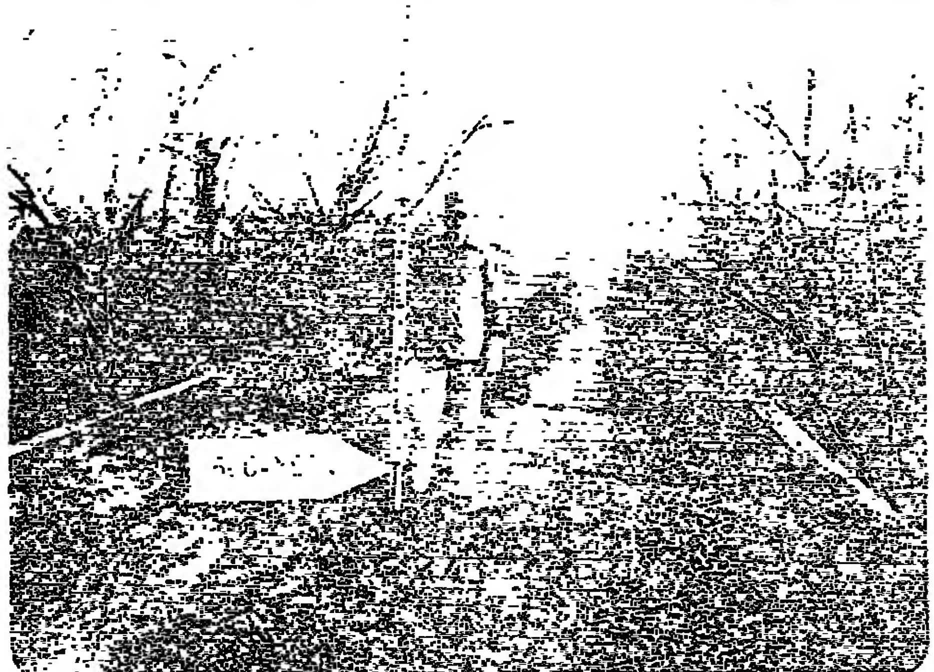


Figure 26 - M 31.72 Private drive in Sec. [illegible]

APPENDIX A

SOILS

The soil information in this report is for only the flood plain area. The soils of Bottineau County are mapped, described, and interpreted in greater detail in the "Soil Survey of Bottineau County, North Dakota." Copies of this survey and help in using soil information are available from the local Soil Conservation Service Office in Bottineau, North Dakota. The soil survey for McHenry County is preliminary and not published.

INTERPRETATION OF SOILS

Interpretations are given in Table I for a number of uses.

Yield Per Acre

The average yields per acre that can be expected of spring wheat under a high level of management are shown in the table. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the soil and the crop. Management can include drainage, erosion control, and protection from flooding; proper planting and seeding rates; use of suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and timely harvesting that insures highest profits. Dashes indicated crops not grown or not suited to the soil.

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The average yields per acre that can be expected of spring wheat under a high level of management are shown in the table. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the soil and the crop. Management can include drainage, erosion control, and protection from flooding; proper planting and seeding rates; use of suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and timely harvesting that insures highest profits. Dashes indicated crops not grown or not suited to the soil.

Land Capability Classification

Land capability classification shows the general suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond

to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, woodland or engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman Numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have slight limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants, require special conservation practices or both.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils have limitations that essentially preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter e, w, s, or c, to the class numeral, for example, IIe.

The letter e shows that the main limitation is risk of erosion unless closegrowing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly because it is shallow, droughty, or stony; and c, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In Class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by w, s or c because the soils in Class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat or recreation.

Important Farmland

Prime farmland is one of several kinds of important farmlands defined by the U.S. Department of Agriculture. It is of major importance in providing the nation's short and long-range needs for food and fiber. Prime farmland is the land best suited to producing food, feed, forage, fiber and oilseed crops. Prime farmland may be in pasture, crops, woodland or other land but it is not urban or built-up land or water areas.

Additional Farmland of Statewide Importance (AFSI) is land, in addition to prime farmlands that is of statewide importance for the production of food, feed, fiber, forage, and oilseed crops. Generally, additional farmlands of statewide importance include those that are nearly prime farmland and that

economically produce high yields of crops when treated and managed according to acceptable farming methods. Some may produce as high a yield as prime farmlands if conditions are favorable.

Additional Farmlands of Local Importance are lands not designated prime or Additional Farmlands of Statewide Importance (AFSI) that can be protected from erosion and are capable of sustained production of the commonly grown crops. Additional Farmlands of Local Importance are designated by a unit of local government. The term "unit of local government" means the government of a county, municipality, town, township, village, or other unit of general government below the state level, or a combination of units of local government acting through an area-wide agency under state law or an agreement for the formulation of regional development policies and plans.

Soil Uses and Limitations

The soils are rated in Table I according to limitations that affect their suitability for playgrounds, picnic areas, dwellings with basements, septic tank absorption fields, sewage lagoons, fill materials for embankments and topsoil. The ratings are based on restrictive soil features such as wetness, slope and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, is the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreations use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, on site assessment of the height, duration, intensity and frequency of flooding is essential.

The degree of soil limitation is expressed as slight, moderate or severe. Slight means that soil properties are generally favorable and that limitations can be overcome or alleviated by planning, design or special maintenance. Severe means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use or by a combination of these measures.

Dwellings

Ratings are made for small dwellings with basements on undisturbed soil. The ratings are based on soil properties, site features and observed performance of the soils. A high water table, flooding, shrink-swell potential and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Septic Tank Absorption Fields

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 to 72 inches is evaluated. The ratings are based on soils properties, site features and observed performance of the soils. Permeability, a high water table, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock, or a cemented pan interf

Playgrounds

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the

season of use. The surface is free of stones and boulders, is firm after rains and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Picnic Areas

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use and do not have slopes, stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Sewage Lagoons

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

The table gives ratings for the natural soil that makes up the lagoon floor. The surface layer and generally 1 to 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock and cemented pans can cause construction problems and large stones can hinder compaction of the lagoon floor.

Embankment, Dikes, and Levees

Embankment, dikes and levees are raised structures of soil material constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of fill material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping and erosion, and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or organic matter, salts or sodium. A high water table affects the amount usable material.

Topsoil

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity and fertility. The ease of excavating, loading and spreading is affected by rock fragments, slope, water table, soil texture and thickness of suitable material. Reclamation of the borrow area is affected by slope, water table, rock fragments, bedrock and toxic material.

Soils rated good have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer and are not so wet that excavation is difficult.

Soils rated fair are sandy soils; loamy soils that have a relatively high content of clay; soils that have only 20 to 40 inches of suitable material; soils that have an appreciable amount of gravel, stones, or soluble salts; or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated poor are very sandy or clayey; have less than 20 inches of suitable material; have a large amount of gravel, stones or soluble salts; have slopes of more than 15 percent; or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and

Soil Symbol Bottineau Co.	McHenry Co.	Soil Name	Sewage Lagoons	Dikes, Levees, Embankments	Topsoil
1		Tonka silt loam	Severe: Ponding	Severe: Ponding	Poor: Thin Layer, Wetness
2		Parnell silty clay loam	Severe: Ponding	Severe: Ponding, Hard to Pack	Poor: Wetness
10		Svea loam, 0 to 3 percent slo	Moderate: Seepage, Wetness	Severe: Piping	Good
	10	Aberdeen-Great Bend Complex,			
		Aberdeen	Moderate: Seepage, Wetness	Severe: Piping, Excess Sodium	Poor: Excess Sodium
		Great Bend	Moderate: Seepage	Moderage: Piping	Fair: Too Clayey
12		Barnes-Svea-Tonka complex, 0			
		Barnes	Moderate: Seepage	Severe: Piping	Fair: Small Stones
		Svea	Moderate: Seepage, Wetness	Severe: Piping	Good
		Tonka	Severe: Ponding	Severe: Ponding	Poor: Thin Layer, Wetness
12B		Barnes-Svea-Tonka complex, 0			
		Barnes	Moderate: Seepage, Slope	Severe: Piping	Fair: Small Stones
		Svea	Moderate: Seepage, Slope, Wetness	Severe: Piping	Good
		Tonka	Severe: Ponding	Severe: Ponding	Poor: Thin Layer, Wetness
14C		Barnes-Buse loams, 3 to 9 pe			
		Barnes	Moderate: Seepage, Slope	Severe: Piping	Fair: Shrink-Swell
		Buse	Moderate: Slope	Severe: Piping	Fair: Shrink-Swell
15E		Buse-Barnes loams, 9 to 25 p			
		Buse	Severe: Slope	Severe: Piping	Poor: Slope
		Barnes	Severe: Slope	Severe: Slope	Poor: Slope

Soil Symbol Bottineau Co.	Soil Symbol McHenry Co.	Soil Name	ewage Lagoons	Dikes, Levees, Embankments	Topsoil
82B	17B	Arvilla sandy loam, 0 to 6 p	evere: Seepage	Severe: Seepage	Poor: Small Stones, Area Reclaim
	18B	Aylmer-Bantry fine sands, 0			
		Aylmer	evere: Seepage, etness	Severe: Seepage, Piping, Wetness	Poor: Too Sandy
		Bantry	evere: Seepage, etness	Severe: Seepage, Piping, Wetness	Poor: Too Sandy
19		Hamerly loam, 0 to 3 percent	evere: Wetness	Severe: Piping, Wetness	Fair: Shrink-Swell
	19B	Aylmer-Minnewaukan complex,			
		Aylmer	evere: Seepage, etness	Severe: Seepage, Piping, Wetness	Poor: Too Sandy
		Minnewaukan	evere: Seepage, etness	Severe: Seepage, Piping, Wetness	Poor: Small Stones, Wetness
25	68	Fargo silty clay	evere: Wetness	Severe: Hard to Pack, Wetness	Poor: Too Clayey, Wetness
26		Fargo and Hegne silty clay,			
		Fargo	evere: Ponding	Severe: Hard to Pack, Ponding	Poor: Too Clayey, Wetness
		Hegne	evere: Ponding	Severe: Ponding	Poor: Too Clayey, Wetness
27		Hegne silty clay	vere: Wetness	Severe: Hard to Pack, Wetness	Poor: Too Clayey
28		Hegne silty clay, saline	vere: Wetness	Severe: Wetness, Hard to Pack	Poor: Too Clayey, Excess Salts
30		Overly silty clay loam	ight	Severe: Piping	Fair: Too Clayey
31		Bearden silty clay loam	vere: Wetness	Severe: Wetness	Fair: Too Clayey
33		Colvin silty clay loam	ve		
34		Colvin silty clay loam, salin			
36		Overly-Great Bend silty clay			
		Overly			
		Great Bend			

Soil Symbol Bottineau Co.	McHenry Co.	Soil Name	Sewage Lagoons	Dikes, Levees, Embankments	Topsoil
40		Gardena silt loam, 0 to	Moderate: Seepage, Wetness	Severe: Piping	Good
42B		Eckman silt loam, 3 to 6	Moderate: Seepage, Slope	Severe: Piping	Good
45		Glyndon silt loam	Severe: Seepage, Wetness	Severe: Piping	Good
46		Glyndon and Bearden soil			
		Glyndon	Severe: Seepage, Wetness	Severe: Piping	Poor: Excess Salts
		Bearden	Severe: Wetness	Severe: Piping	Poor: Excess Salts
50	65	Embden fine sandy loam,	Severe: Slope	Severe: Seepage, Piping	Good
	50	Colvin silt loam	Severe: Wetness	Severe: Wetness	Poor: Wetness
	51	Colvin silt loam, saline	Slight	Severe: Wetness	Poor: Wetness, Excess Salts
51B		Egeland fine sandy loam,	Severe: Seepage	Severe: Piping, Seepage	Good
53	101	Wyndmere fine sandy loan	Severe: Seepage, Wetness	Severe: Piping	Fair: Thin Layer
54		Ulen loamy fine sand, 0	Severe: Seepage, [illegible]	Severe: Seepage, Piping	Fair: Too Sandy
55	91	Hecla loamy fine sand, (			
56B		Maddock loamy fine sand			
	62B	Egeland fine sandy loam,			
65	157	Swenoda fine sandy loam			
69		Arveson loam			

Soil Symbol Bottineau Co.	McHenry Co.	Soil Name	Sewage Lagoons	Dikes, Levees, Embankments	Topsoil
71		Arveson loam, wet	Severe: Seepage, Ponding	Severe: Seepage, Piping, Ponding	Poor: Wetness
73	105	Letcher fine sandy loam, 0	Severe: Seepage	Severe: Piping, Excess Sodium	Poor: Excess Sodium
	73	Fossum and Arveson soils			
		Fossum	Severe: Seepage, Wetness	Severe: Piping, Seepage, Wetness	Poor: Thin Layer
		Arveson	Severe: Seepage, Wetness	Severe: Piping, Seepage, Wetness	Fair: Small Stones, Thin Layer
74B		Cresbard-Svea loams, 0 to			
		Cresbard	Moderate: Slope	Severe: Excess Sodium	Poor: Excess Sodium
		Svea	Moderate: Slope, Seepage, Wetness	Severe: Piping	Good
75		Aberdeen-Overly silt loam			
		Aberdeen	Moderate: Seepage, Wetness	Severe: Piping, Excess Sodium	Poor: Excess Sodium
		Overly	Slight	Severe: Piping	Good
	76	Gardena loam, 0 to 3 perce	Moderate: Seepage, Wetness	Severe: Piping	Good
79		Divide loam	Severe: Seepage, Wetness	Severe: Seepage	Poor: Small Stones, Area Reclaim
	79	Glyndon loam, saline	Severe: Seepage, Wetness	Severe: Piping	Poor: Excess Salts
	80	Glyndon loam	Severe: Seepage, Wetness	Severe: Piping	Good
	82	Great Bend-Overly complex,			
		Great Bend	Moderate: Seepage	Severe: Piping	Fair: Too Clayey
		Overly	Moderate: Seepage	Severe: Piping	Fair: Too Clayey
83D		Sioux loam, 0 to 15 percer	Severe: Seepage, Slope	Severe: Seepage	Poor: Small Stones, Area Reclaim

Soil Symbol Bottineau Co.	McHenry Co.	Soil Nam	Sewage Lagoons	Dikes, Levees, Embankments	Topsoil
97		Aberdeen-Exline silt loa			
		Aberdeen	Moderate: Seepage, Wetness	Severe: Piping, Excess Sodium	Poor: Excess Sodium
		Exline	Severe: Wetness	Severe: Excess Sodium	Poor: Excess Sodium
100		Colvin silty clay loam,	Severe: Flooding, Ponding	Severe: Ponding	Poor: Wetness
104		Parnell silty clay loam,	Severe: Ponding	Severe: Hard to Pack, Ponding	Poor: Wetness
	107B	Lohnes-Claire loamy coar			
		Lohnes	Severe: Seepage	Severe: Seepage, Ponding	Fair: Small Stones, Area Reclaim
		Claire	Severe: Seepage	Severe: Seepage, Piping	Fair: Too Sandy
110		Exline silt loam	Severe: Wetness	Severe: Excess Sodium	Poor: Excess Sodium
	110	Ludden silty clay, ponde	Severe: Flooding, Ponding	Severe: Piping, Hard to Pack	Poor: Wetness, Too Clayey
111	151	Stirum fine sandy loam	Severe: Seepage, Ponding	Severe: Seepage, Piping, Ponding	Poor: Wetness, Escess Sodium
	111	Ludden silty clay	Severe: Flooding	Severe: Hard to Pack, Wetness	Poor: Too Clayey, Wetness
	112B	Maddock-Heckla loamy fi			
		Maddock	Severe: Seepage	Severe: Seepage, Piping	Poor: Thin Layer
		Hecla	Severe: Seepage, Wetness	Severe: Seepage, Piping	Poor: Thin Layer
	124	Marysland loam	Severere: Seepage, Wetness	Severe: Seepage, Wetness	Fair: Area Reclaim, Small Stones, Thin Layer
	137	Harriet silt loam	Severe: Flooding, Wetness	Severe: Piping, Wetness, Excess Sodium	Poor: Wetness, Excess Sodium

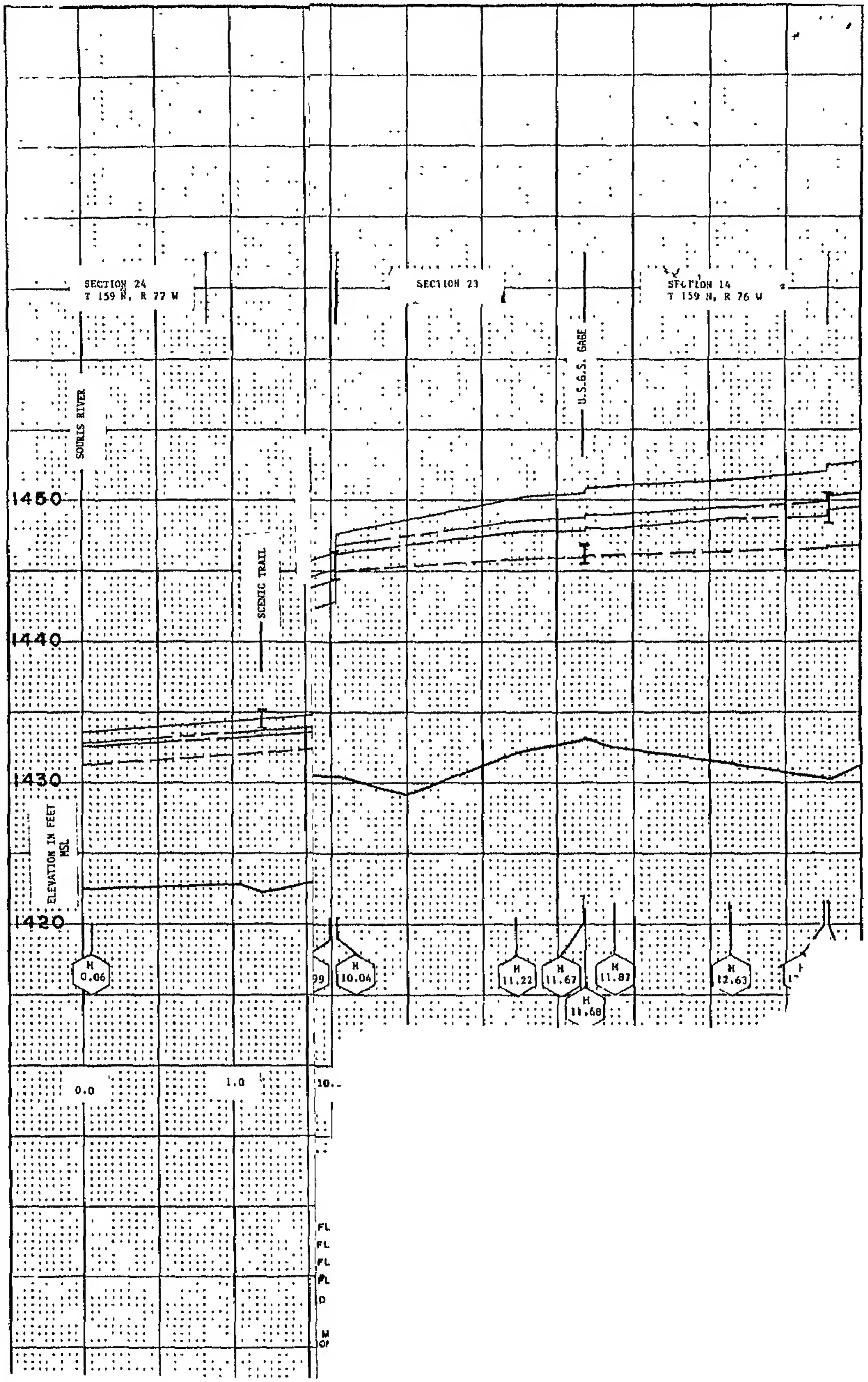
Soil Symbol Bottineau Co.	Soil Symbol McHenry Co.	Soil Name	Sewage Lagoons	Dikes, Levees, Embankments	Topsoil
	163B	Towner loamy fine sand, 0 t	Severe: Seepage, Wetness	Severe: Piping	Poor: Thin Layer
	172	Ulen fine sandy loam, 0 to	Severe: Seepage, Wetness	Severe: Seepage, Piping	Fair: Too Sandy

* Could be designated AFLI in McHenry County.

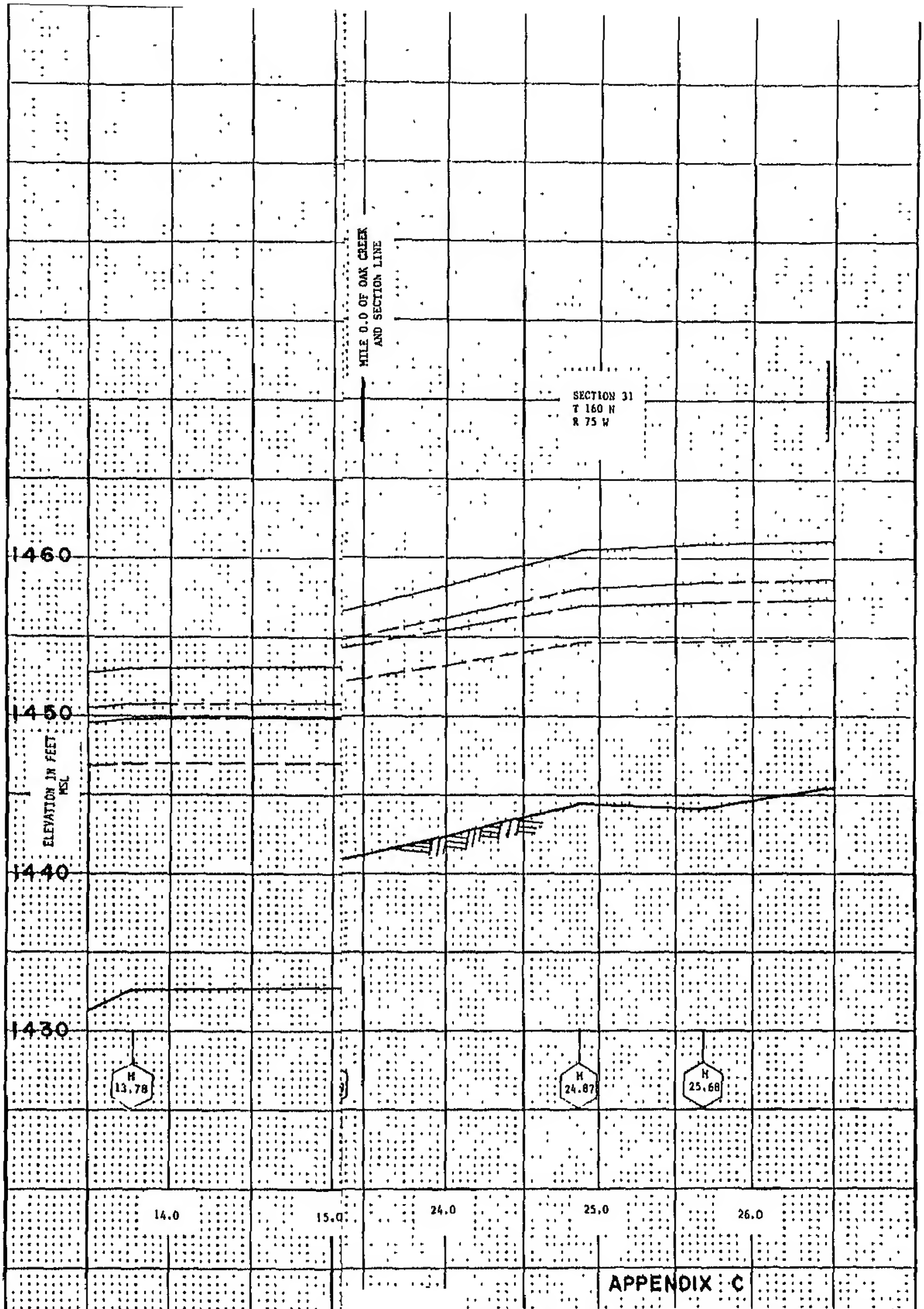
1/ P=prime, PWD=Prime where drained, AFSI=additio
AFLI=additional farmlands of local importance,

2/ All yields are for drained areas of the poorly

3/ Construction of dwellings, septic tanks and se
floodplain. However, if construction is neces
flood hazard and soil restrictions presented i



SECTION 24
T 159 N, R 77 W
SECTION 23
SECTION 14
T 159 N, R 76 W
SOURIS RIVER
U.S.G.S. GAGE
SCENIC TRAIL
1450
1440
1430
1420
ELEVATION IN FEET
MSL
H 0.06
H 10.04
H 11.22
H 11.67
H 11.68
H 11.87
H 12.63
0.0
1.0



APPENDIX C

FLOOD
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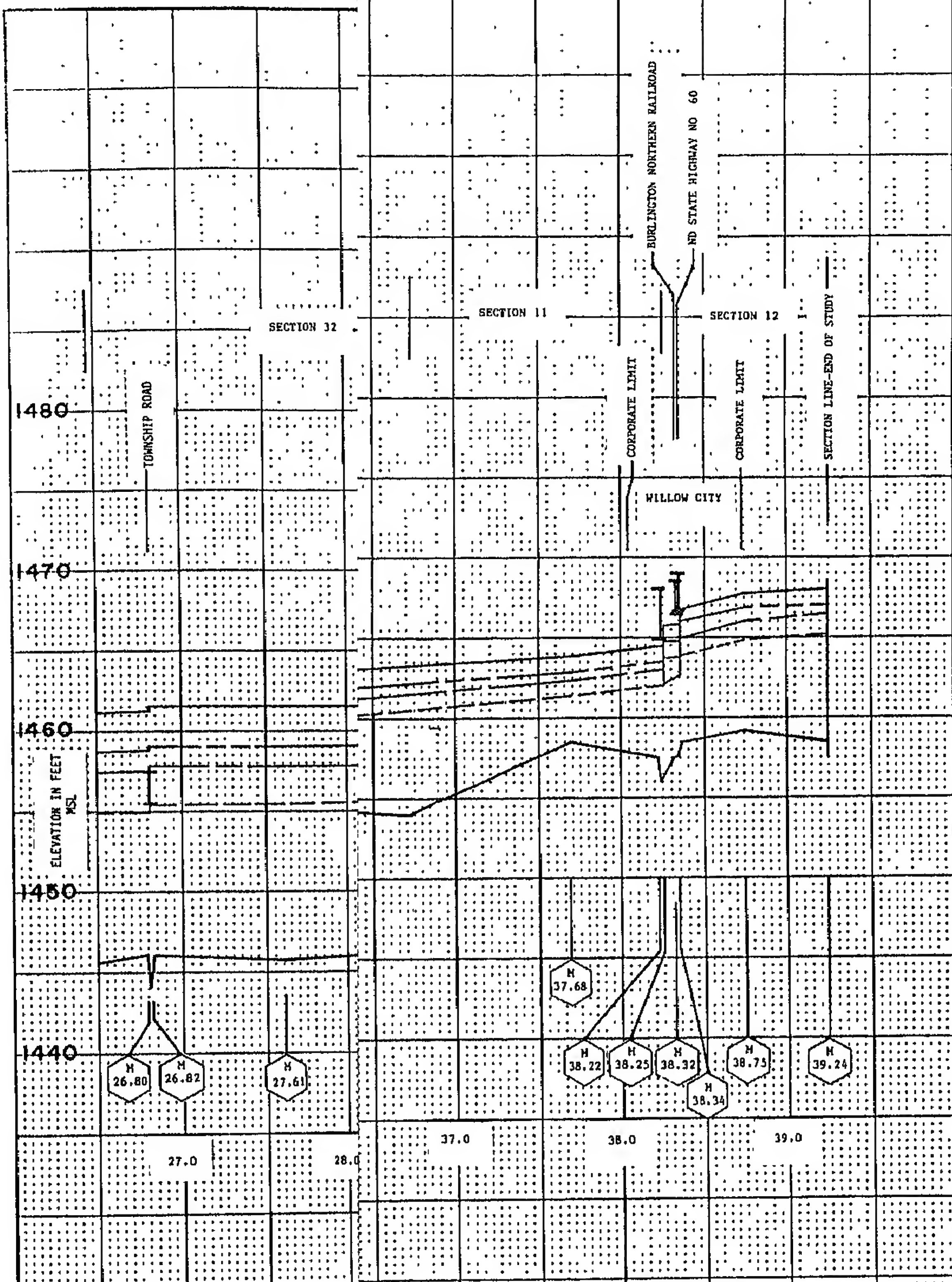
ION LOCATION

WILLOW CREEK PROFILES
OAK AND WILLOW CREEK
FLOOD PLAIN MANAGEMENT STUDY
McHENRY AND BOTTINEAU COUNTIES, NO. DAK.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed J. G. DUSEK Date 1/84
Drawn GEORGE WALISER 1/85
Traced
Approved by
Title
Title
Sheet
Drawing No



APPENDIX C

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TION LOCATION

WILLOW CREEK PROFILES
OAK AND WILLOW CREEK
FLOOD PLAIN MANAGEMENT STUDY
BOTTINEAU COUNTY NORTH DAKOTA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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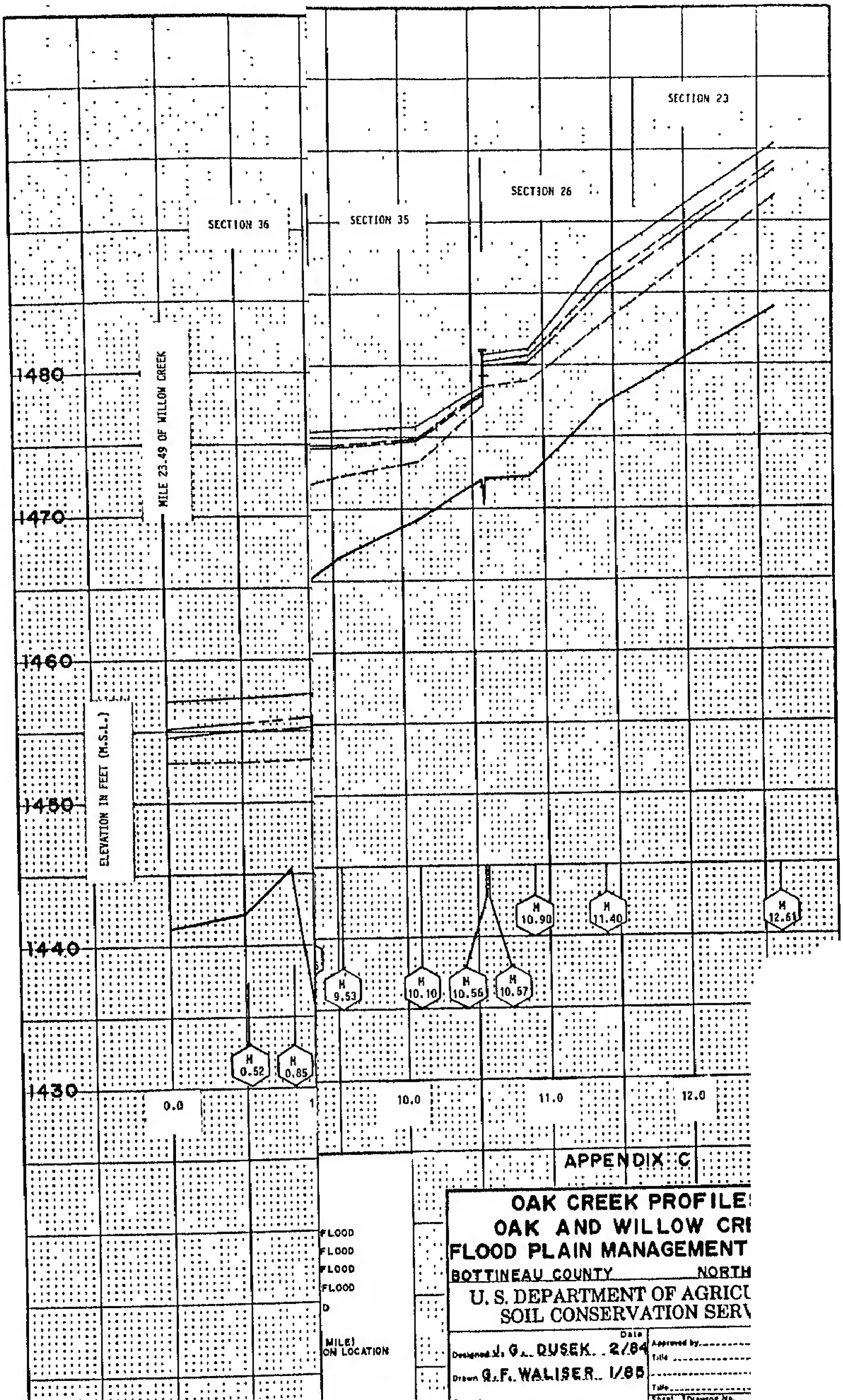
SECTION 23
SECTION 26
SECTION 36
SECTION 35
1480
1470
1460
1450
1440
1430
MILE 23.49 OF WILLOW CREEK
ELEVATION IN FEET (M.S.L.)
M 10.90
M 11.40
M 12.61
M 9.53
M 10.10
M 10.56
M 10.57
M 0.52
M 0.85
0.0
10.0
11.0
12.0
APPENDIX C
OAK CREEK PROFILE
OAK AND WILLOW CR
FLOOD PLAIN MANAGEMENT
BOTTINEAU COUNTY
NORTH
U. S. DEPARTMENT OF AGRIC
SOIL CONSERVATION SER
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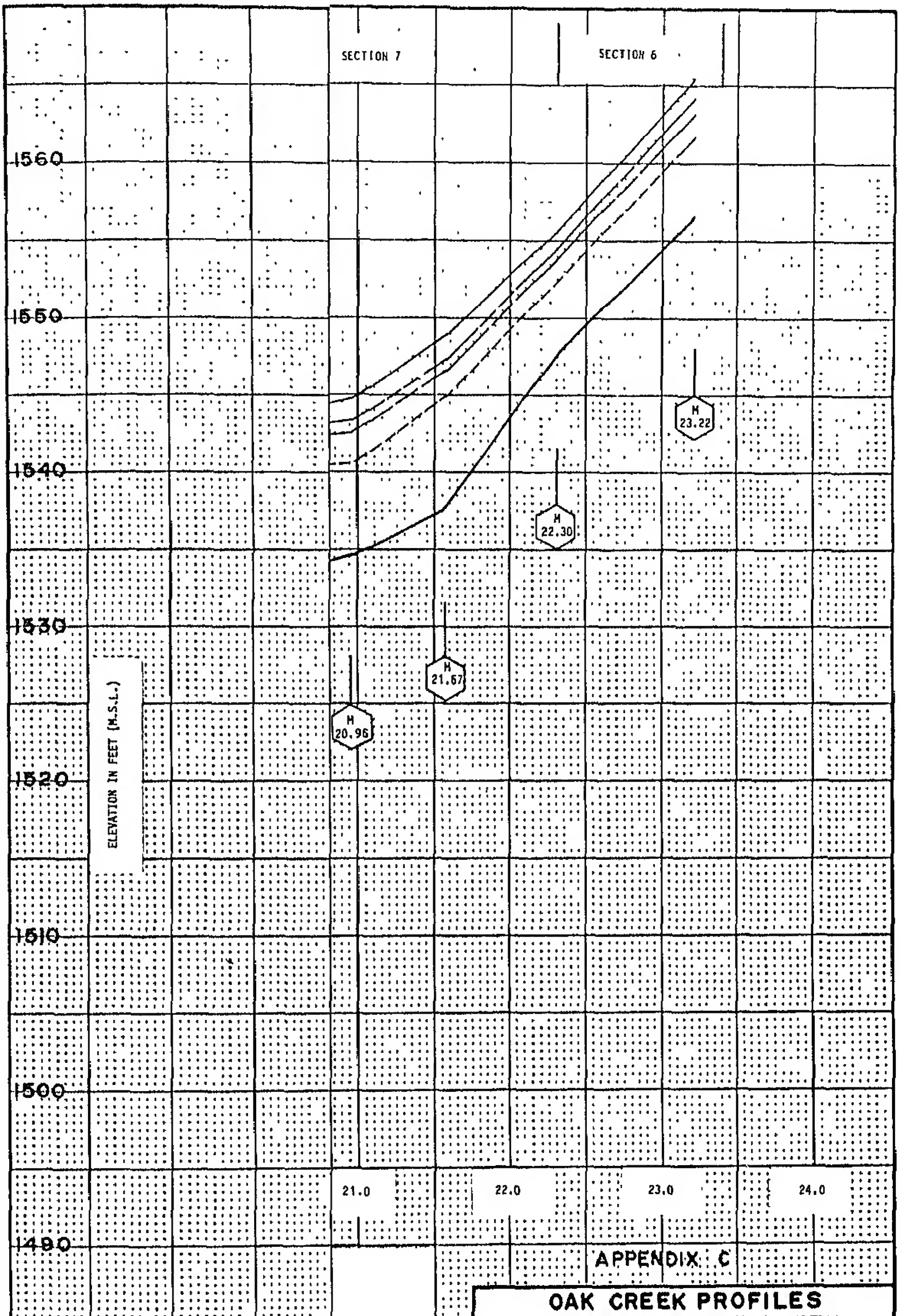
ON LOCATION
Designed J. G. DUSEK 2/84
Drawn G. F. WALISER 1/85
Date
Approved by
Title



APPENDIX C

OAK CREEK PROFILES
OAK AND WILLOW CREEK
FLOOD PLAIN MANAGEMENT STUDY

BOTTINEAU COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed J. G. DUSEK	Date 2/84	Approved by
Drawn G. F. WALISER	1/85	Title
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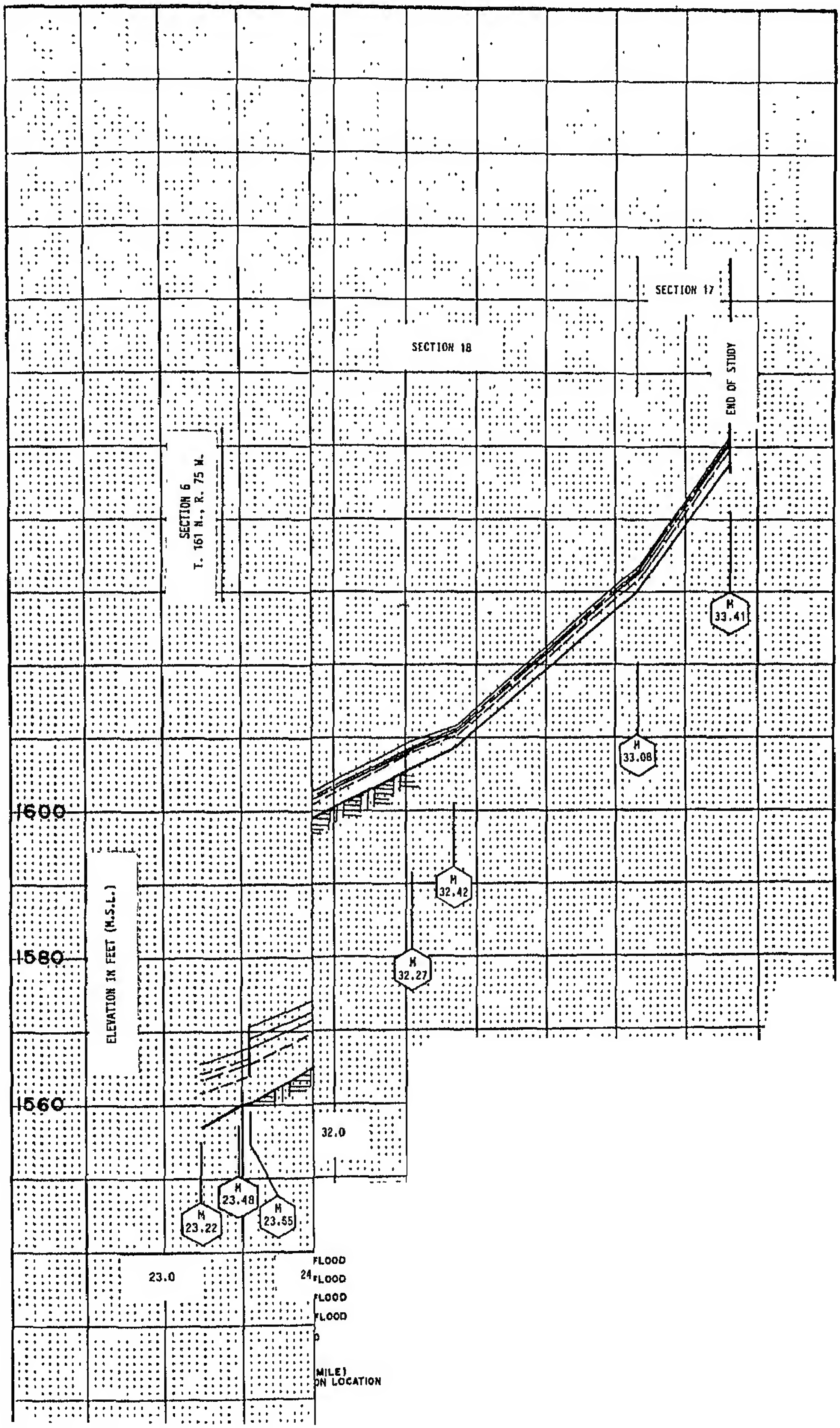
SECTION 17
SECTION 18
END OF STUDY
SECTION 6
T. 161 N., R. 75 W.
M 33.41
M 33.08
M 32.42
M 32.27
1600
1580
1560
ELEVATION IN FEET (M.S.L.)
32.0
M 23.48
M 23.22
M 23.55
23.0
24
FLOOD
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FLOOD
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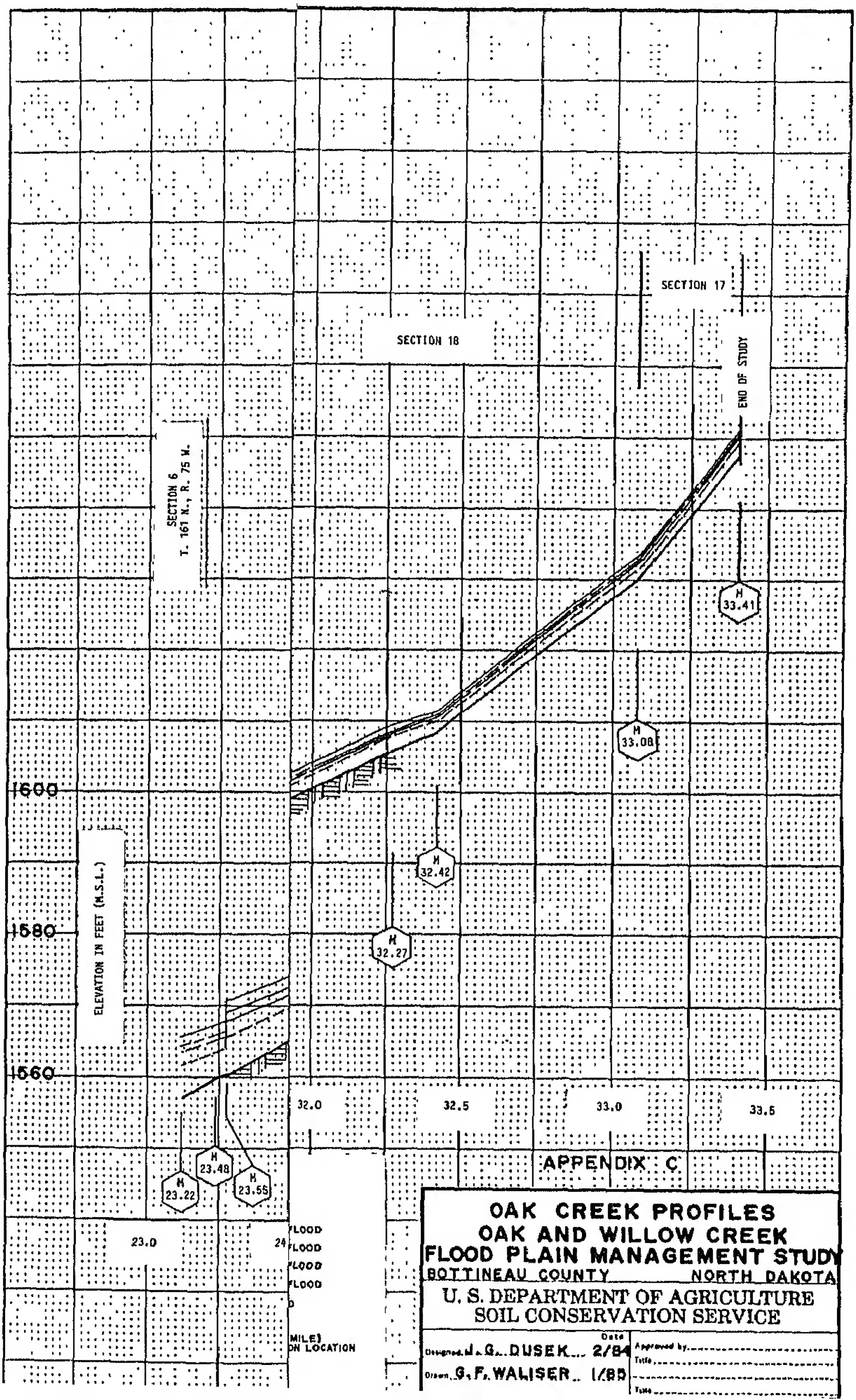
ON LOCATION



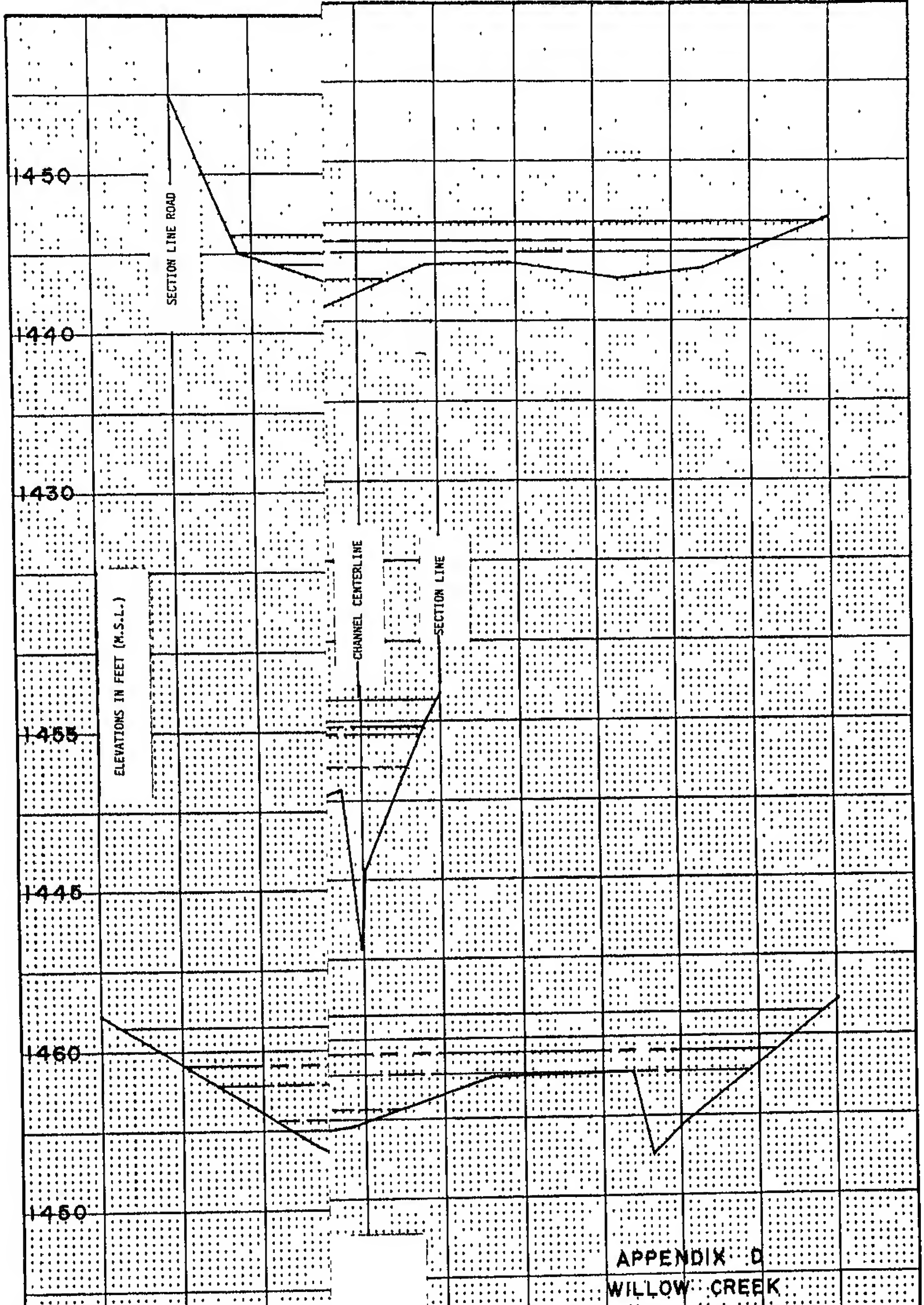
APPENDIX C

OAK CREEK PROFILES
OAK AND WILLOW CREEK
FLOOD PLAIN MANAGEMENT STUDY

BOTTINEAU COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
Designed J. G. DUSEK	2/84	Approved by
Drawn G. F. WALISER	1/85	Title



APPENDIX D
WILLOW CREEK

SAMPLE CROSS SECTIONS
OAK AND WILLOW CREEK
FLOOD PLAIN MANAGEMENT STUDY
BOTTINEAU AND McHENRY COS., NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
Designed R.D. FORNESS	7/85	Approved by
Drawn G. F. WALISER	7/85	Title
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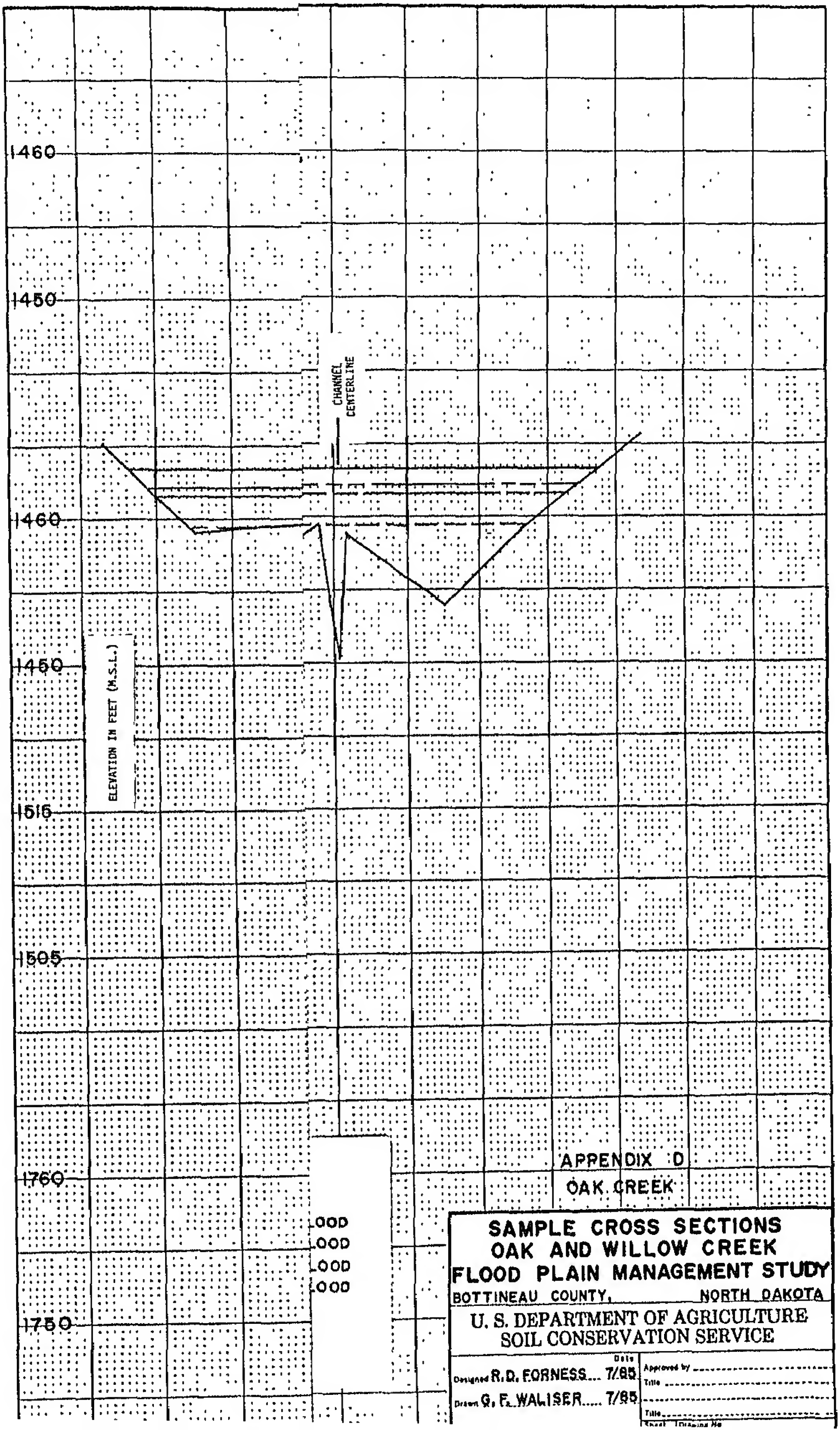

APPENDIX D

OAK CREEK

SAMPLE CROSS SECTIONS
OAK AND WILLOW CREEK
FLOOD PLAIN MANAGEMENT STUDY

BOTTINEAU COUNTY, NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
Designed R. D. FORNESS	7/85	Approved by
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Drawn G. F. WALISER	7/85	Title
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APPENDIX E

DISCHARGE-FREQUENCY DATA

OAK - WILLOW

McHENRY AND BOTTINEAU COUNTIES

BETWEEN CHANNEL MILES	DRAINAGE 1/ AREA (SQUARE MILES)	500-YEAR FREQ. FLOOD DISCHARGE	100-YEAR FREQ. FLOOD DISCHARGE	50-YEAR FREQ. FLOOD DISCHARGE	10-YEAR FREQ. FLOOD DISCHARGE
WILLOW CREEK					
0.0					
	1400	25,000 2/	15,000 2/	11,000 2/	4,150
8.01					
	1400	33,000	17,500	12,000	4,150
10.04					
	730	21,640	11,260	7,970	2,750
23.29					
	610	19,000	10,000	6,800	2,450
36.04					
	500	16,500	8,800	6,000	2,200
39.24					
OAK CREEK					
0.0					
	115	5,400 3/	3,130 3/	2,200	850
5.67					
	71	3,600 3/	2,200 3/	1,600	630
8.63					
	52	2,800 3/	1,780 3/	1,300	520
10.90					
	52	3,600	1,850	1,300	520
20.46					
	35	2,800	1,460	1,000	400
33.41					

1/ Contributing drainage area only. Does not include 69 sq. miles above Lake Metigoshe plus other non-contributing drainage area.

2/ Discharge reduced to reflect overland flow to the Souris River between mile 0.0 and 8.01.

3/ Discharge reduced to reflect a breakout area at channel mile 10.58.

APPENDIX F

WATER SURFACE ELEVATION - FREQUENCY DATA

WILLOW CREEK

McHENRY AND BOTTINEAU COUNTIES

WILLOW CREEK EXISTING CONDITION

CHANNEL MILE 1/	500-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)
0.04	1433.6	1432.9	1432.5	1431.3
3.40	1436.4	1435.4	1435.0	1433.8
5.00	1437.8	1436.8	1436.4	1435.2
5.97	1439.4	1438.5	1438.1	1437.2
5.99	1440.5	1439.6	1438.9	1437.6
7.05	1441.0	1440.0	1439.4	1438.0
8.01	1442.0	1441.2	1440.6	1439.3
9.48	1444.3	1443.1	1442.4	1440.8
9.99	1446.2	1445.0	1444.3	1442.6
10.04	1447.7	1446.8	1446.3	1445.0
11.22	1450.3	1448.6	1447.8	1445.9
11.67	1450.6	1448.8	1447.9	1446.0
11.68	1450.8	1449.0	1448.1	1446.1
11.87	1451.1	1449.1	1448.2	1446.1
12.63	1451.5	1449.6	1448.7	1446.4
13.26	1452.1	1449.9	1448.9	1446.6
13.29	1452.6	1450.4	1449.4	1446.7

1/ Channel mile 0.0 is at the confluence of the Souris River

WILLOW CREEK EXISTING CONDITION

CHANNEL MILE	500-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)
13.78	1453.1	1450.8	1449.8	1447.0
17.20	1453.4	1451.0	1449.9	1447.3
18.26	1453.7	1451.4	1450.3	1448.1
18.28	1453.9	1451.6	1450.6	1448.4
19.04	1454.6	1452.3	1451.5	1449.5
21.18	1455.2	1453.0	1452.2	1450.3
21.75	1455.6	1453.4	1452.7	1450.8
21.76	1455.8	1453.9	1453.4	1451.2
21.93	1456.1	1454.4	1453.8	1451.7
23.29	1456.4	1454.7	1454.1	1452.1
24.87	1460.6	1458.2	1457.0	1454.7
25.68	1461.0	1458.5	1457.3	1454.8
26.80	1461.3	1458.8	1457.5	1454.9
26.82	1461.5	1459.0	1457.8	1455.4
27.61	1461.5	1459.1	1457.8	1455.5
29.06	1461.6	1459.2	1457.9	1455.7
31.71	1461.8	1459.5	1458.4	1456.8
33.71	1461.9	1459.8	1458.8	1457.3
36.04	1463.0	1461.7	1461.1	1460.0
37.68	1463.9	1462.9	1462.4	1461.4
38.22	1464.5	1463.5	1463.0	1461.9
38.25	1465.7	1464.7	1463.7	1462.1
38.32	1465.8	1464.7	1463.8	1462.5
38.34	1466.9	1466.1	1465.0	1462.8
38.75	1467.8	1466.9	1466.1	1464.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX F

WATER SURFACE ELEVATION - FREQUENCY DATA

OAK CREEK

BOTTINEAU COUNTY

OAK CREEK EXISTING CONDITION

CHANNEL MILE 1/	500-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)
0.52	1457.3	1455.6	1455.0	1452.8
0.85	1457.5	1455.8	1455.1	1453.0
1.02	1457.6	1456.0	1455.3	1453.0
1.39	1457.8	1456.3	1455.6	1453.6
2.52	1458.3	1457.0	1456.4	1455.0
3.26	1459.2	1458.0	1457.4	1455.9
3.28	1460.3	1459.2	1458.1	1456.2
3.51	1460.7	1459.6	1458.7	1456.7
3.89	1462.2	1460.8	1459.8	1457.8
3.93	1462.5	1461.4	1461.0	1458.4
4.30	1462.7	1461.6	1461.1	1458.5
4.85	1463.1	1462.0	1461.4	1459.1
4.88	1463.3	1462.2	1461.6	1459.3
5.27	1463.4	1462.2	1461.6	1459.3
5.67	1463.4	1462.2	1461.6	1459.4
5.69	1463.4	1462.2	1461.6	1459.4
6.01	1463.4	1462.2	1461.6	1459.4

1/ Channel mile 0.0 is at the confluence of the Willow Creek

CHANNEL MILE	500-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)
OAK CREEK EXISTING CONDITION				
6.51	1463.4	1462.2	1461.6	1459.4
6.58	1463.5	1462.2	1461.6	1459.5
7.15	1463.5	1462.3	1461.6	1459.6
7.45	1463.5	1462.3	1461.7	1460.1
7.51	1464.6	1464.2	1464.0	1461.6
8.19	1464.7	1464.2	1464.0	1461.9
8.63	1468.4	1467.8	1467.6	1466.3
8.75	1470.9	1469.7	1469.0	1467.2
8.77	1471.4	1469.9	1469.2	1467.3
8.79	1472.1	1470.5	1469.6	1467.5
9.22	1473.3	1472.1	1471.6	1470.7
9.26	1475.4	1474.4	1474.3	1471.6
9.53	1475.5	1474.5	1474.4	1472.2
10.10	1475.6	1474.8	1474.7	1473.2
10.56	1478.5	1478.1	1478.0	1477.0
10.57	1480.8	1480.3	1480.0	1478.0
10.90	1481.2	1480.7	1480.3	1478.9
11.40	1487.1	1485.9	1485.1	1482.8
12.61	1495.4	1494.2	1493.6	1491.6
13.59	1500.9	1499.8	1499.2	1498.2
14.68	1505.4	1504.3	1503.6	1502.7
16.02	1511.4	1510.4	1509.9	1509.2
16.07	1515.2	1514.8	1514.6	1511.3

OAK CREEK EXISTING CONDITION

CHANNEL MILE	500-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)
16.47	1515.9	1515.2	1514.9	1512.5
16.99	1517.2	1516.4	1515.9	1514.5
18.28	1526.7	1525.2	1524.6	1523.3
19.46	1533.4	1532.2	1531.7	1530.6
19.80	1537.3	1536.1	1535.3	1534.0
19.82	1539.4	1538.0	1536.6	1534.3
20.46	1542.9	1541.6	1541.0	1539.7
20.53	1543.8	1542.8	1542.2	1540.3
20.96	1544.8	1543.4	1542.6	1540.6
21.57	1549.0	1547.4	1546.6	1545.0
22.30	1555.7	1554.6	1553.9	1552.5
23.22	1565.6	1564.2	1563.3	1561.7
23.48	1567.3	1565.9	1565.1	1563.6
23.55	1570.7	1569.0	1567.8	1565.6
24.77	1579.9	1578.7	1578.1	1577.3
24.81	1581.5	1580.7		
25.00	1582.8	1582.0		
25.05	1585.6	1584.3		
25.73	1592.1	1590.4		
30.63	1694.6	1693.1		
31.22	1714.2	1713.0		
31.60	1728.4	1727.4		

OAK CREEK EXISTING CONDITION

CHANNEL MILE	500-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION IN FEET (M.S.L.)
31.62	1733.4	1732.4	1731.8	1728.6
31.65	1734.0	1733.0	1732.4	1730.4
32.27	1758.8	1757.6	1757.1	1755.9
32.42	1762.9	1762.0	1761.4	1760.3
33.08	1807.4	1805.8	1805.2	1803.6
33.41	1842.4	1841.0	1840.4	1839.0

APPENDIX G

INVESTIGATIONS & ANALYSES

Surveys

A bench mark circuit was established throughout the study area using existing U.S.G.S. Coast and Geodetic Bench Marks. Elevation reference marks are scattered throughout the study area. These reference marks can be used to determine flood elevations as indicated in this flood hazard analyses. Detailed locations, descriptions and elevations can be obtained from Appendix J. Third order levels were used as the base of accuracy in field surveys.

A total of 109 channel and flood plain cross sections, covering a channel distance of 67.85 miles, were field surveyed and analyzed.

The geometry of all bridges and culverts were measured and used in computing the water surface profiles.

All cross sections are located on the photomaps (Appendix B, Sheets 1 to 17).

Photogrammetry

High and low level aerial photography flights were flown in April 1983. The low level aerial photography was used for stereo plotting the 100 and 500 year hydrologic flood lines and securing other topographic features. The high level photography was used for compilation of the final photo maps.

Hydrology and Hydraulics

Peak discharges for the 10-, 50-, 100-, and 500-year frequencies are based on a study of U.S.G.S. stream gage data from records of Willow Creek and nearby watersheds having similar hydrologic characteristics. Stations used in this study include Willow Creek near Willow City, Mauvais Coulee near Cando, Boundary Creek near Landa, Egg Creek near Granville, Willow Creek at Dunseith, Egg Creek near Deering, Egg Creek near Ruthville, and Egg Creek near Glenburn.

Peak discharges vary throughout the study area depending on the size and other characteristics of the contributing drainage area.

The drainage area at the beginning of the study area is approximately 1850 square miles, with approximately 1400 square miles contributing runoff and reduced to 104 square miles at the upper end of Oak Creek, with 35 square miles contributing runoff.

Water surface elevations for the 10-, 50-, 100- and 500-year flood events were computed using the Soil Conservation Service WSP-2 computer program, which performs subcritical backwater computations by a modified standard step method. The program includes head loss computations at restricted sections such as roadway bridge openings or culverts.

Roughness coefficients (Manning's "n") used in the hydraulic computations were chosen using Soil Conservation Service guidelines. The channel value varied from 0.040 to 0.085 while the flood plain value ranged from 0.060 to 0.12. To determine the starting elevations at the Souris River, water s profiles were computed using friction slope values parallel to the floo slope.

From mile 0.0 to 8.01 of Willow Creek, topography limits the maximum depth of flow within the Willow Creek flood plain. When this depth is exceeded, excess water flows directly into the Souris River. Discharges were reduced to reflect this outflow. No attempt was made to route these overflows from Willow Creek. Discharges were reduced for this reach by the following amounts:

10 year - 0 cfs

50 year - 1000 cfs

100 year - 2500 cfs

500 year - 8000 cfs

On Oak Creek, two breakout areas were identified for the 100 and 500 year frequencies. Backup water from the railroad bridge at mile 7.51 causes a minor amount of water to flow into the Stone Creek Watershed between sections 4 and 5, T. 160 N., R. 76 W. This is shallow flow and is not reflected in the routed discharges. At approximately mile 10.6, part of the flow for the 100 and 500 year discharge flows into the Stone Creek Watershed. This discharge was considered in the downstream water surface profiles. Discharges were reduced from mile 0.0 to 10.58 by the following amounts:

50 year - 0 cfs

100 year - 70 cfs

500 year - 800 cfs

The hydraulic analyses for this study were based on unobstructed flow. The flow elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly and do not fail. The 100-year flood was computed to emphasize the effect of constrictions (bridge openings) on flooding and provide a basis for analyzing future improvements. Future projections indicate that expected encroachment will affect the flood stages a slight amount within the study area. The 100-year flood also serves as the base flood which HUD considers as a minimum for flood insurance requirements.

APPENDIX H

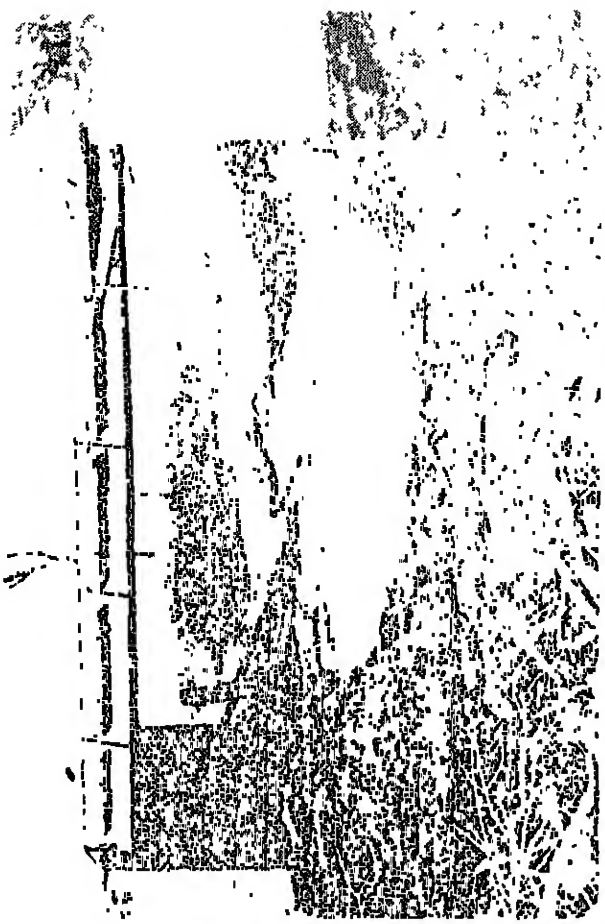
EXISTING BRIDGES AND CULVERTS

Bridges and culverts existing at the time of study and used to develop the water surface profile data contained in this document are shown pictorially on the following pages.

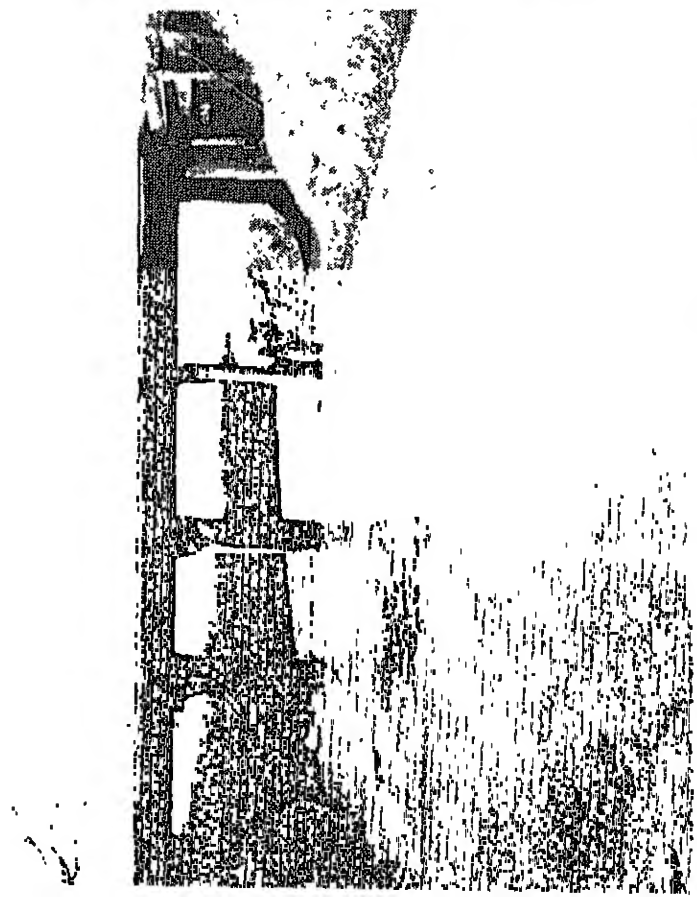
The pictures should be helpful in the future to visually check which bridging was in place at the time of study, which were restrictive or in need of replacement and which have been subsequently replaced thus affecting localized flood plains.

WILLOW CREEK EXISTING BRIDGES

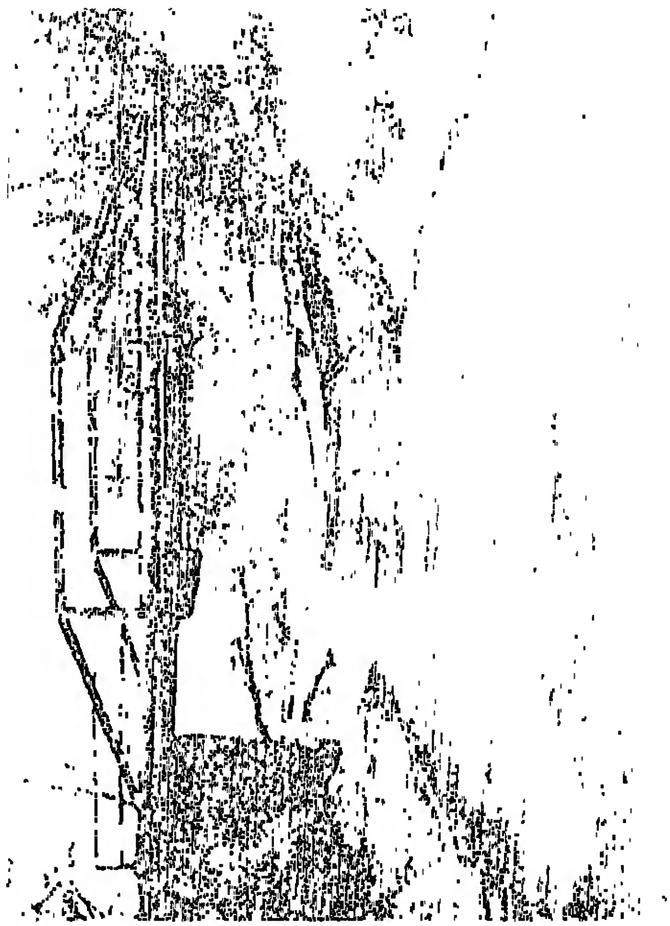
M 1.20 in Section 19, T. 159 N., R. 76 W.



M 5.99 in Section 20, T. 159 N., R. 76 W.

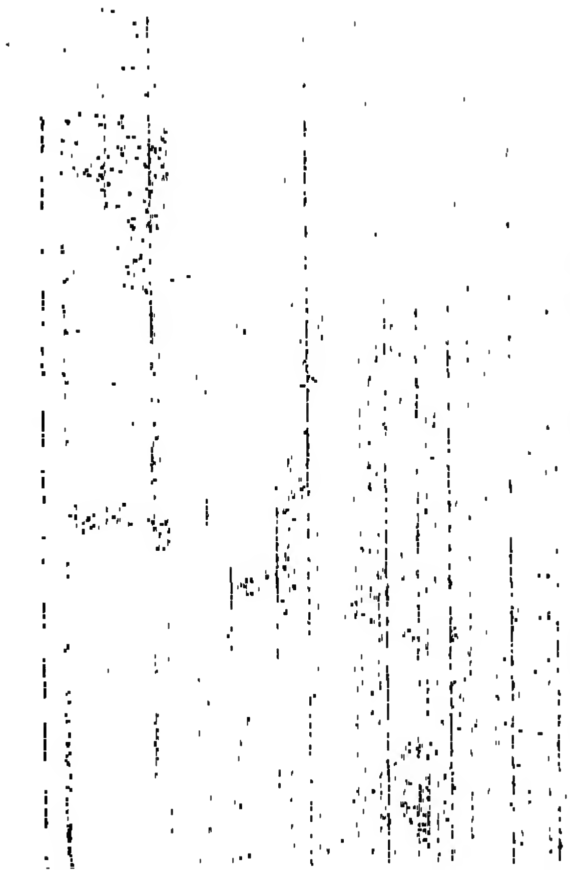


M 10.04 Sections 22 and 23, T. 159 N., R. 76 W.



M 11.68 Sections 14 and 23, T. 159 N., R. 76 W.

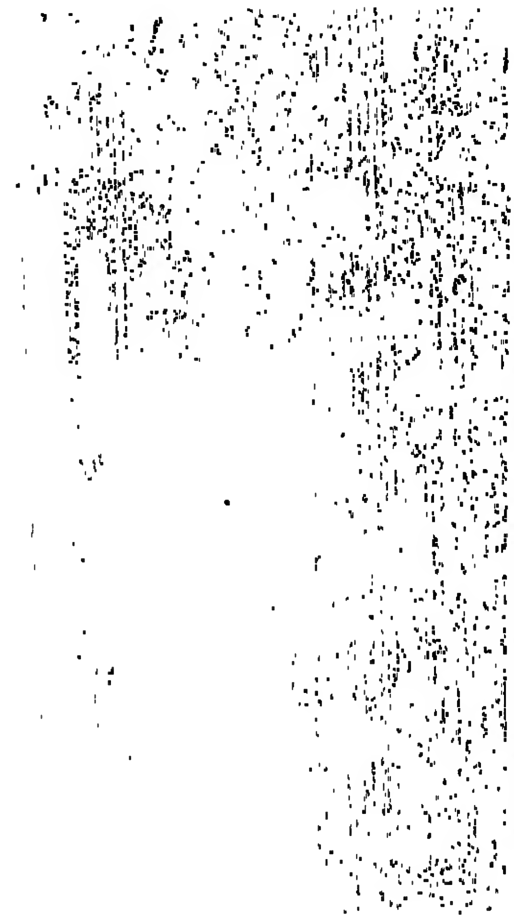
WILLOW CREEK EXISTING BRIDGES



M 13.29 Sections 11 and 14, T. 159 N., R. 76 W.

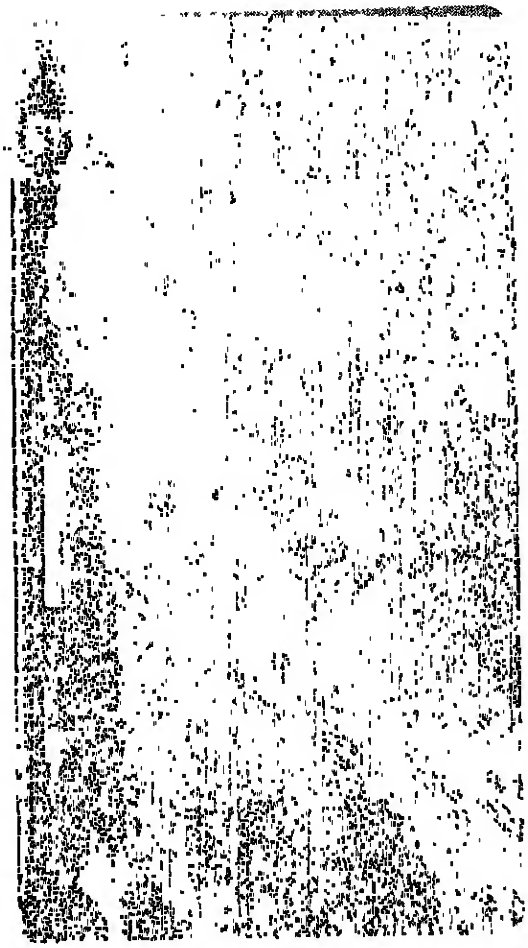
M 18.28 Sections 1, 2, 11 and 12, T. 159 N., R. 76 W.

M 21.76 Sections 1, T. 159 N., R. 76 W. and 36, T. 160 N., R. 76 W.



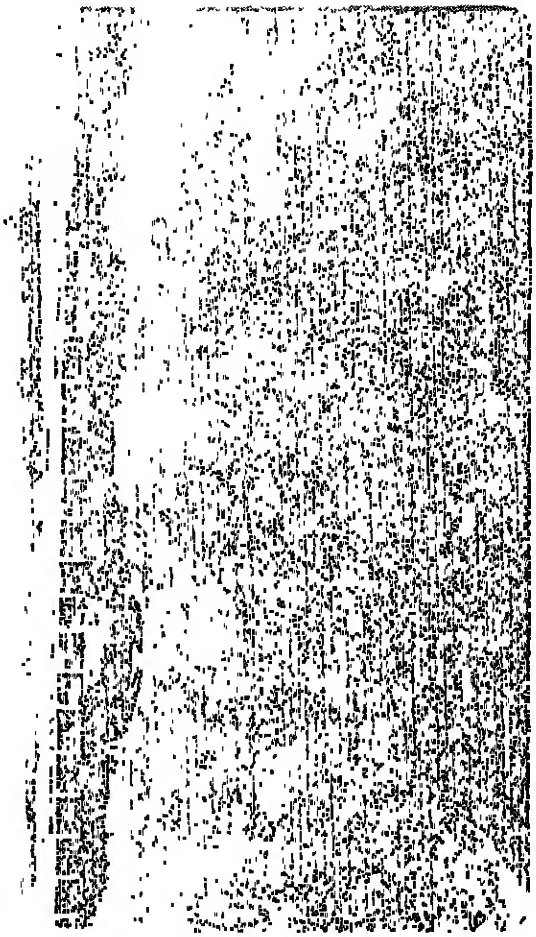
M 26.82 in Section 32, T. 160 N., R. 75 W.

WILLOW CREEK EXISTING BRIDGES

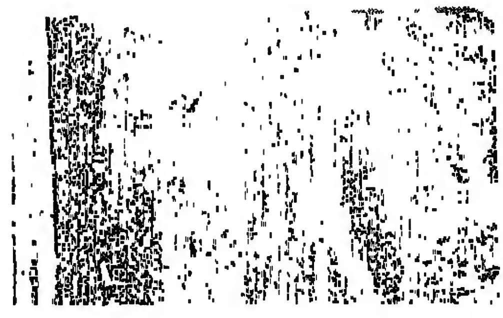


M 38.25 Sections 11 and 12, T. 159 N., R. 75 W.

M 26.82 Overflow Channel in Section 32,
T. 160 N., R. 75 W.



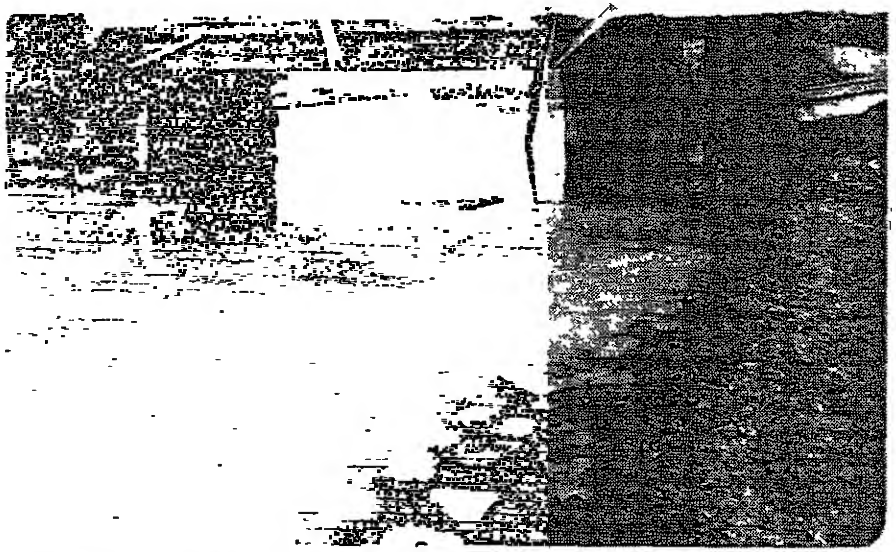
M 38.34 Highway 60 Bridge at Willow City, ND



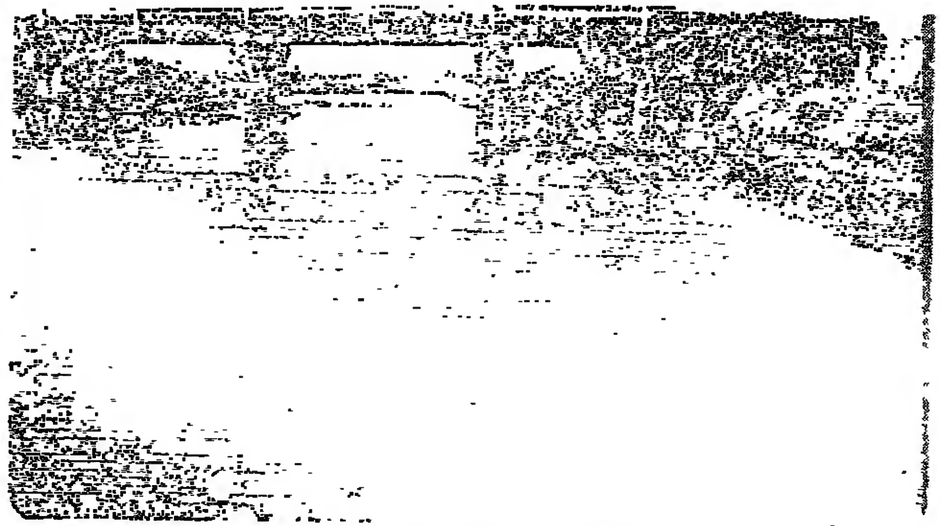
llow City, ND

M 38.32 B.N. Railroad Bri

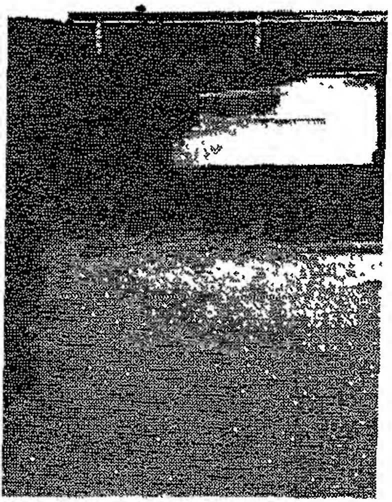
OAK CREEK EXISTING BRIDGES

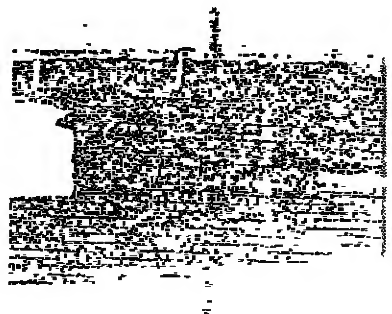


M 1.02 Sections 25 and 36, T. 160 N., R. 76 W.

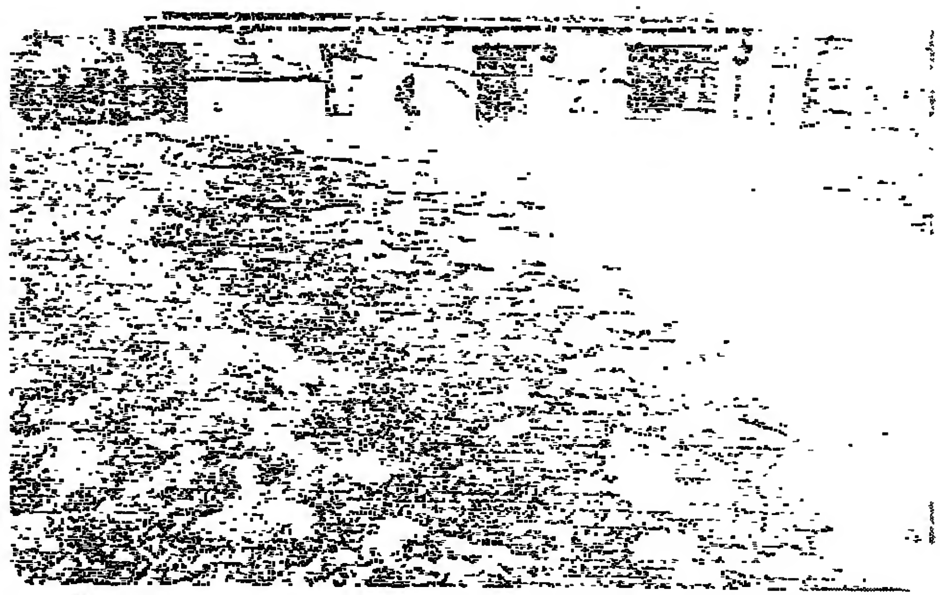


M 3.28 Sections 19 and 30, T. 160 N., R. 75 W.





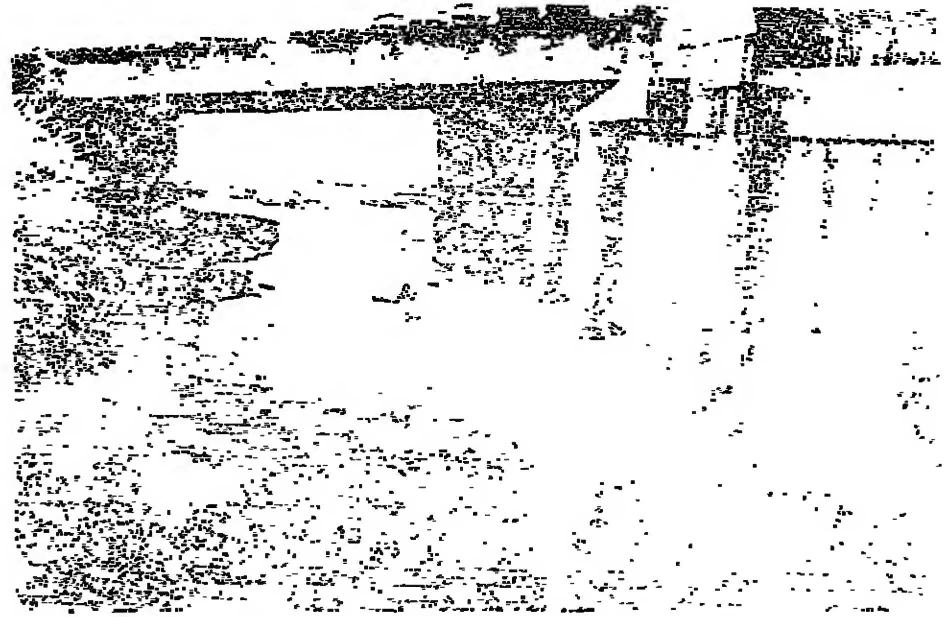
M 3.93 Sections 19, 24, T. 160 N. R 75 W. and



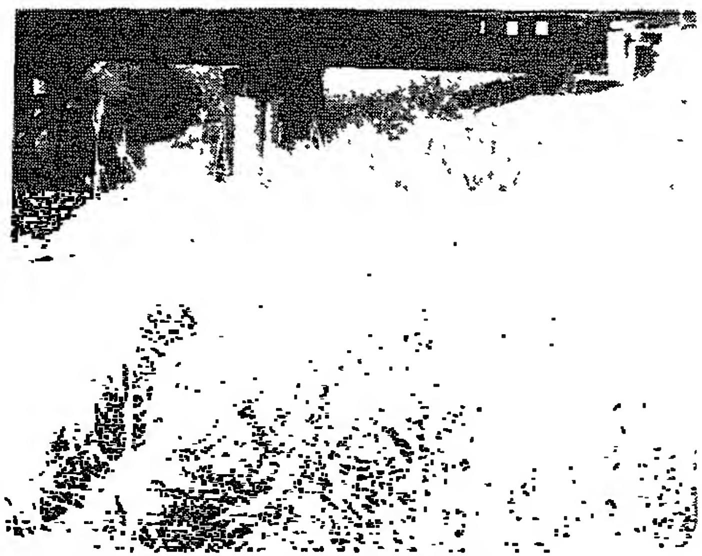
M 4.88 Sections 13 and 24, T. 160 N., R. 76 W.

OAK CREEK EXISTING BRIDGES

M 5.69 Sections 13 and 14, T. 160 N., R. 76 W.



M 6.58 Sections 11 and 14, T. 160 N., R. 76 W.

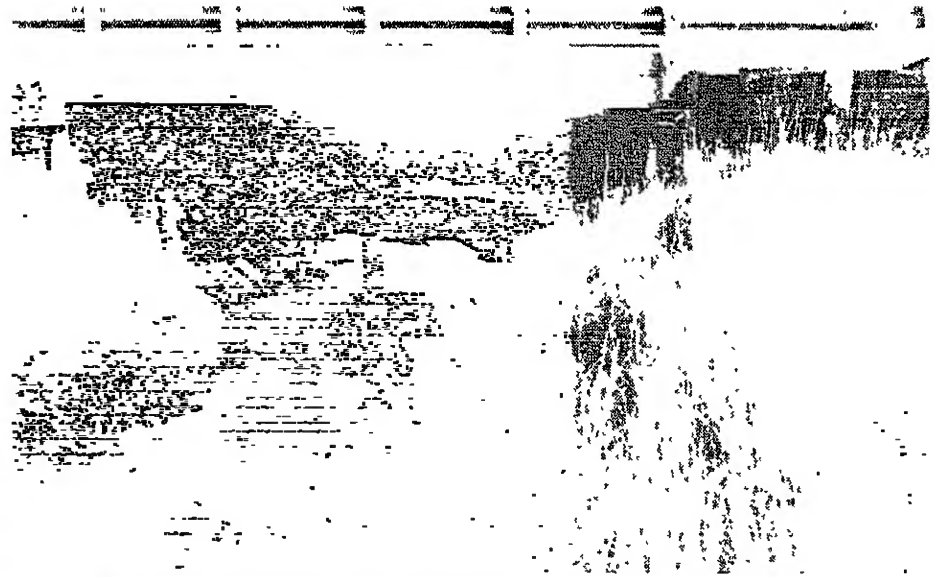


. Railroad Bridge in Section 10,
160 N., R. 76 W.

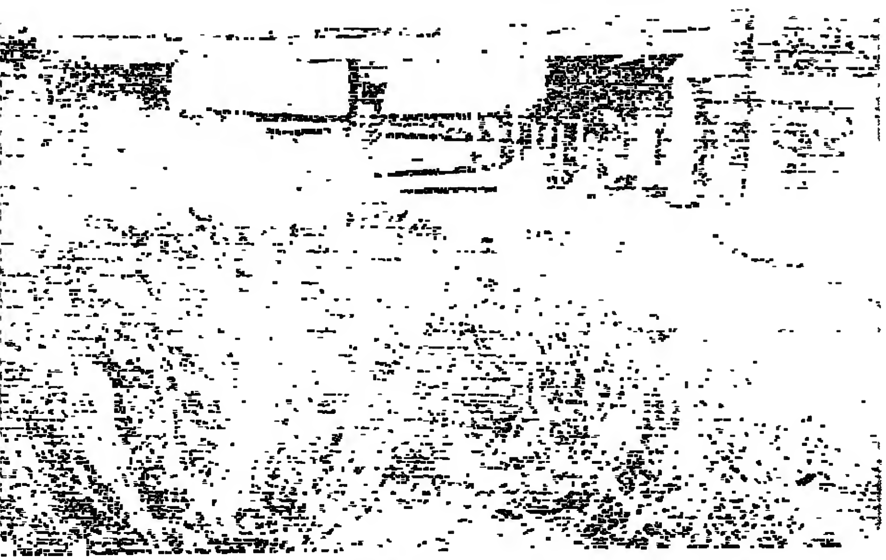
M 7.68 Sections 3 and 10, T. 160 N., R. 76 W.

OAK CREEK EXISTING BRIDGES

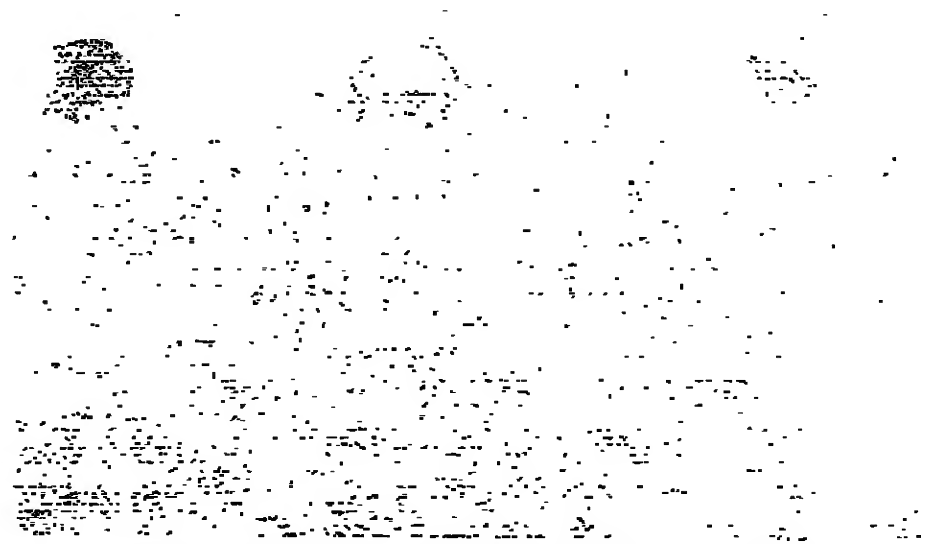
M 8.77 Sections 3, T. 160 N., R. 76 W.
and 36, T. 161 N., R. 76 W.



M 9.26 Sections 35 and 36, T. 161 N., R. 76 W.

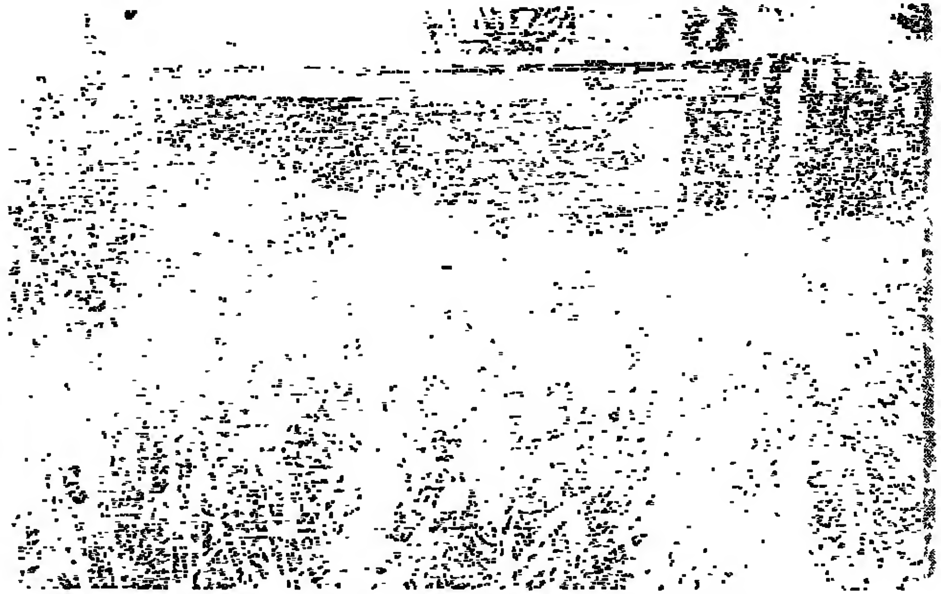


M 10.57 Sections 26 and 35, T. 161 N., R. 76 W.

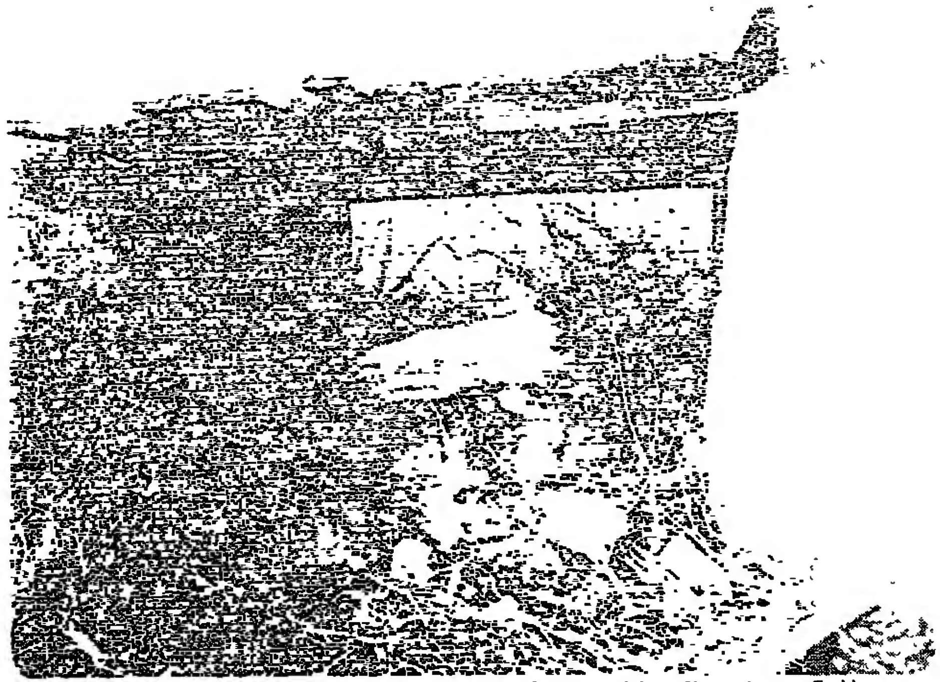


M 16.07 Sections 13 and 14, T. 161 N., R. 76 W.

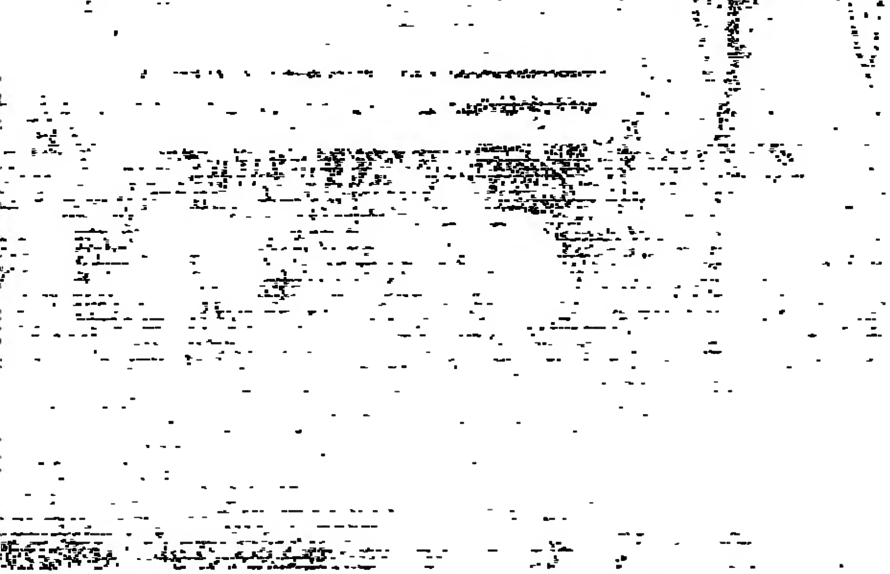
M 19.82 Sections 7 and 18, T. 161 N., R. 75 W.



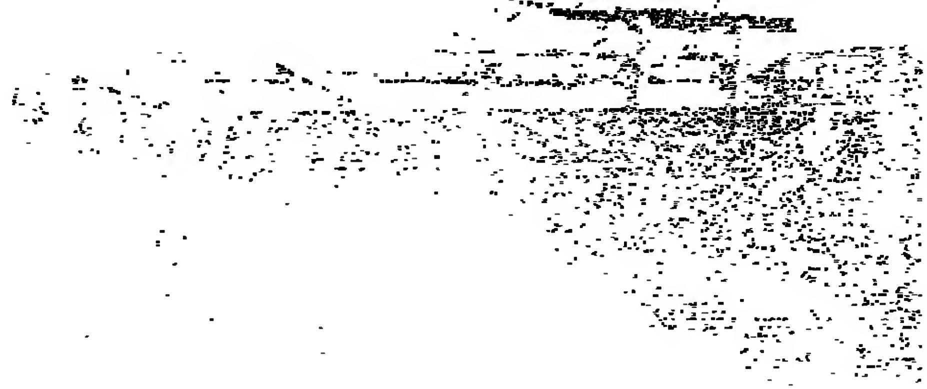
M 20.53 Private Drive Bridge in Section 7, T. 161 N., R. 75 W.



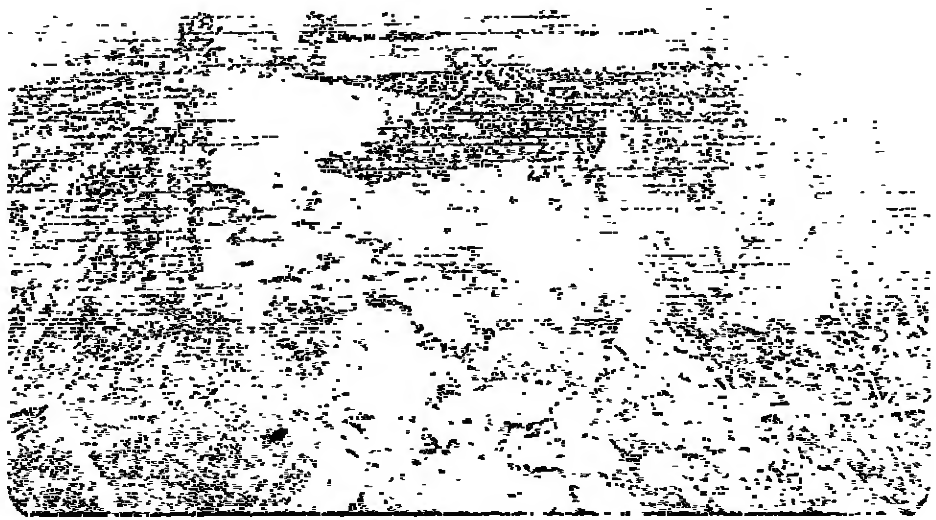
M 23.[illegible] Bridge in Section 1, [illegible] N., R. [illegible]6 W.



M 24.81 Sections 1, T. 161 N., R. 76 W. and 36, T. 162 N., R. 76 W.



M 25.05 Sections 31, T. 162 N., R. 75 W. and 36, T. 162 N., R. 76 W.



M 31.62 Private Drive Bridge in Section 18, T. 162 N., R. 75 W.

APPENDIX I

GLOSSARY

Acre-Foot -- The amount of water that will cover one acre to a depth of one foot. Equals 43,560 cubic feet.

Backwater -- The resulting high water surface in a given stream due to a downstream restriction or high stages in an intersecting stream.

Channel -- A natural or artificial watercourse with definite bed and banks to confine and conduct continuously or periodically flowing water.

Cubic Feet Per Second -- Rate of fluid flow at which one cubic foot of fluid passes a measuring point in one second (cfs).

Discharge -- The rate of flow or volume per unit of time. In this report discharge is expressed in cubic feet per second (cfs).

Flood -- An overflow of water onto lands not normally covered by water. The inundation is temporary and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake or other body of standing water.

Flood Frequency -- An expression of how often a flood event of a given magnitude will, on the average, be equaled or exceeded. The word "frequency" often is omitted in discussing a flood event for the purpose of abbreviat

Examples:

10-year flood or 10-year frequency flood - the flood which can be expected to be equaled or exceeded on an average of once in 10 years; and which would have a 10 percent chance of being equaled or exceeded in any given year.

50-year flood - ...two percent chance...in any given year.

100-year flood - ...one percent chance...in any given year.

500-year flood - ...two-tenths percent chance...in any given year.

Flood Peak or Peak Discharge -- The highest stage or discharge attained during a flood.

Flood Plain, Flood Prone Area or Flood Hazard Area -- Land adjoining a stream (or other body of water) which may be temporarily covered by flood water.

Flood Plain Encroachment -- Placement of fill or structures in the flood plain which may impede flood flow and cause backwater.

Flood Proofing -- A combination of structural provisions, changes or adjustments to properties and structures subject to flooding for the reduction or elimination of flood damages to properties, water and sanitary facilities, structures and contents of buildings in a flood hazard area.

Flood Routing -- Computation of the changes in streamflow as a flood moves downstream. The results provide hydrographs of discharge versus time at given points on the stream.

Flood Stage -- The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area.

Hydrograph -- A plotted curve showing the rise and fall of flood discharge with respect to time at a specific point on a stream.

Natural Storage Area -- In this report, refers to depressional areas, marshes, lakes and swamps that temporarily store a portion of the surface runoff.

Natural Values -- Values existing in an area untouched by the civilization and society (i.e. - natural flood storage and

Riparian Land -- Land situated along the bank of a stream or water.

Runoff -- In this report, refers to the portion of precipitation (including snowmelt) that flows across the land surface and contributes to stream or flood flow.

Stage Discharge Curve -- A plotted curve showing the variation of discharge with water surface elevation at a point on a stream.

Stage-Storage Curve -- A plotted curve showing the accumulated storage available for floodwater upstream from a point on a stream versus the stage at that point.

Valley Cross Section -- The relationship of the elevation of the ground to the horizontal distance across a valley perpendicular to the direction of flow.

Watershed -- A drainage basin or area which collects and transmits runoff to the outlet of the basin.

Watershed Boundary or Drainage Boundary -- The divide separating one watershed from another.

Water Surface Profile -- The relationship of water surface elevation to channel elevation at points along a strea

surface elevation for the peak of a spe

conditions at any given time.

APPENDIX J

ELEVATION REFERENCE MARKS

OAK CREEK AND WILLOW CREEK FLOOD PLAIN MANAGEMENT STUDY

R.M. No.	Elevation in Feet (MSL)	R.M.'s Description
1-1	1706.34	On top of the north end of a 24" CMP at the State Highway Department maintenance yard at the west quarter line of Section 20, T. 162 N., R. 75 W.
10	1584.38	Railroad spike in bridge abutment at the SW corner of a bridge over Oak Creek approximately 350 feet north of the SE corner of Section 36, T. 162 N., R. 76 W.
1-9A	1534.90	Railroad spike in bridge abutment at the NW corner of a bridge over Oak Creek near the SW corner of Section 7, T. 161 N., R. 75 W.
1-11	1512.69	Chiseled X on the east end of the middle arch pipe on Oak Creek near the SW corner of Section 13, T. 161 N., R. 76 W.
1-12A	1481.10	Chiseled X on bolt head on wheel guard at the SW corner of a bridge over Oak Creek between Sections 26 and 35, T. 161 N., R. 76 W.
1-13	1475.75	Chiseled X on anchor bolt on wheel guard at the NW corner of bridge over Oak Creek near the SE corner of Section 35, T. 161 N., R. 76 W.
1-17	1465.59	Chiseled X on bolt at the NW corner of a railrod bridge, 0.4 feet above the tie elevation between Sections 10 and 11, T. 160 N.. R. 76 W.

R.M. No.	Elevation in Feet (MSL)	R.M.'s Description
1-18	1461.82	Chiseled X on bolt on NE corner of bridge over Oak Creek between Sections 11 and 14, T. 160 N., R. 76 W.
1-19	1460.09	Spike through bottle cap in headwell at the SE corner of a bridge over Oak Creek between Sections 13 and 14, T. 160 N., R. 76 W.
1-20	1459.25	Spike through bottle cap in rail post at the SE corner of a bridge over Oak Creek between Sections 13 and 24, T. 160 N., R. 76 W.
22A	1458.87	Chiseled X on bolt on SW corner of a bridge over Oak Creek between Sections 19 and 30, T. 160 N., R. 75 W.
1-25	1456.34	Chiseled X on bolt, 14 feet west of the SE corner of a bridge on Oak Creek approximately 800 feet west of the NE corner of Section 36, T. 160 N., R. 76 W.
1-28	1453.15	Chiseled X on bolt through wheel guard at the NW corner of a bridge over Willow Creek approximately 1,400 feet west of the SE corner of Section 36, T. 160 N., R. 76 W.
1	1461.29	Top of west end of 24 inch corrugated pipe at Conrad Schuster's driveway in the SW quarter of Section 11, T. 159 N., R. 75 W.
	1468.85	In Willow City, North Dakota, top of hydrant at intersection of 3rd Street and Main Street.
	1471.37	Top of hydrant at intersection of 1st Street and Main Street.
	1470.63	Top of hydrant at southeast corner of intersection of State Highway 60 and Main Street.

R.M. No.	Elevation in Feet (MSL)	R.M.'s Description
102	1457.96	Chiseled X on wheel guard bolt at SW corner of bridge over Willow Creek in the SW quarter of Section 32, T. 160 N., R. 75 W.
105	1463.30	Spike in base of power pole near the SE corner of Section 29, T. 160 N., R. 75 W.
106	1471.29	Top of north witness post for underground cable near the NE corner of Section 33, T. 160 N., R. 75 W.
107	1467.92	Top of north witness post for underground cable near the NE corner of Section 34, T. 160 N., R. 75 W.
1-29	1449.77	Chiseled X on the NW wingwall of a bridge over Willow Creek near the SE corner of Section 11, T. 159 N., R. 76 W.
1-31	1450.77	Chiseled X on wheel guard on the SE corner of a bridge over Willow Creek between Sections 11 and 14, T. 159 N., R. 76 W.
1-33	1446.27	Chiseled X on a bolt near the NE corner of a bridge over Willow Creek near the SW corner of Section 23, T. 159 N., R. 76 W.
1-36	1439.27	Chiseled X on SW wingwall of a bridge over Willow Creek in Section 20, T. 159 N., R. 76 W.
1-35A	1435.57	Chiseled X on a bolt near the SW corner of a bridge over Willow Creek in Section 19, T. 159 N., R. 76 W.

APPENDIX K

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